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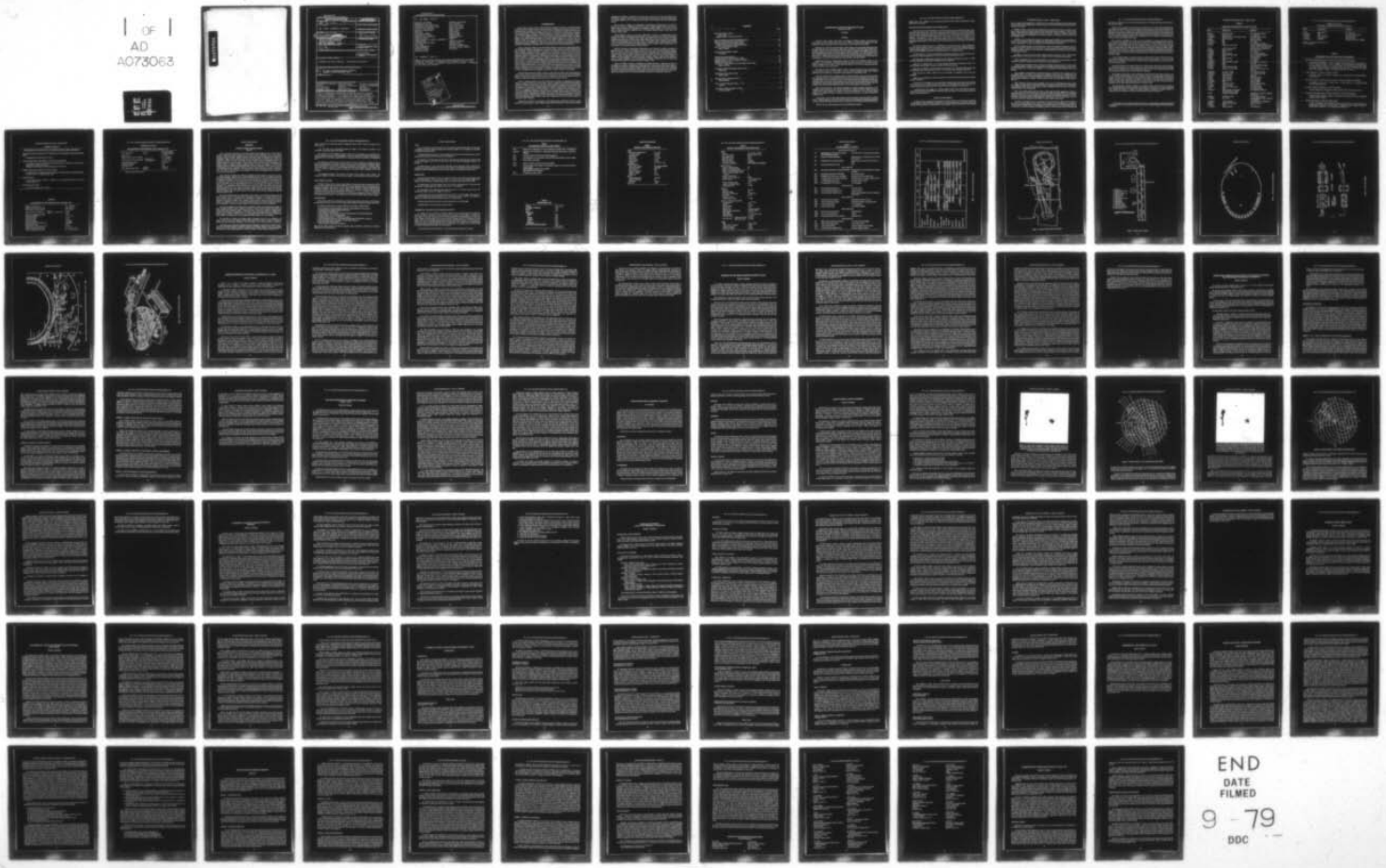

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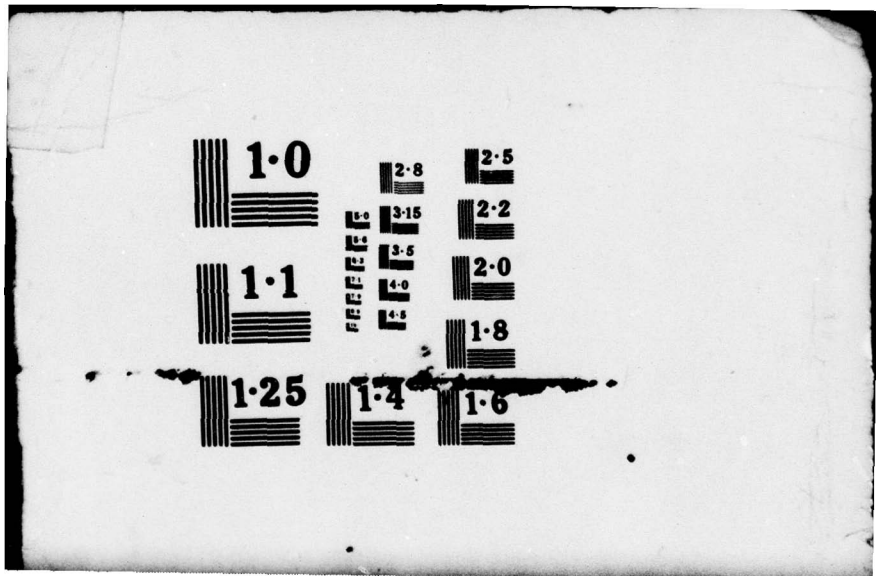
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X-rays	Synaptic transmission	Coastal oceanography
VUV radiation	Primates	Kuroshio
Storage rings	Brain behavior	Microbiology
Membrane biophysics	Molecular biophysics	Toxinology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR

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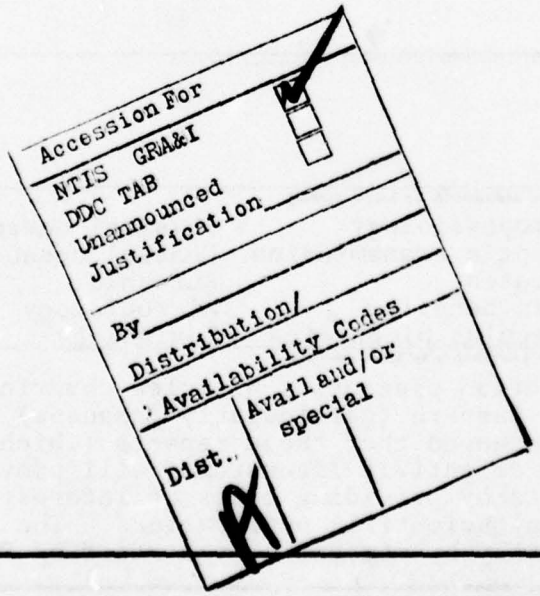
19. Key Words (cont'd)

Acoustic emission
Mechanical testing
Nondestructive evaluation
Structural integrity tests
Fracture and fatigue
Pattern recognition
Robotics
Molecular theory
Correlation energy
Chemical oscillations
Heme proteins
Spectroscopy of organic compounds
Fluorescence
Infrared spectroscopy
Red tides
Dinoflagellates
Lake sediments
Kuroshio rings
Marine geology
Thermal discharges
Trace metals
Seto Inland Sea
Hydraulic model
Metal corrosion
Oshoro Maru
Ushio Maru
Hokusei Maru
Planktology
Appendicularia
Copepods
Krill
Infrared imagery
Marine snow
Sediment traps
Sea ice forecasting
Academia Sinica Taiwan
Pollution

20. ABSTRACT (cont'd)

Tokyo, with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.



CONTRIBUTORS

Herman Winick is Deputy Director, Stanford Synchrotron Radiation Laboratory of the Stanford Linear Accelerator Center and Adjunct Professor, Stanford University. He formerly served as Assistant Director of the Cambridge Electron Accelerator and Lecturer in Harvard University's Department of Physics and concurrently as Guest in the Department of Physics at Massachusetts Institute of Technology. In 1976 Winick was a consultant to the Solid State Sciences Committee of the National Research Council of the National Academy of Sciences. Also in 1976 he participated as Director of the Summer School on Synchrotron Radiation Research in Alghero, Sardinia, and as visiting scientist and lecturer at the Frascati National Laboratory. As a guest of the Soviet Academy of Sciences in 1977, Winick visited the Synchrotron Radiation Laboratories in the Soviet Union and during the same year presented an invited talk at the Orsay Conference on Synchrotron Radiation Instrumentation and New Developments. In 1978 he visited synchrotron radiation laboratories and universities in Japan under the sponsorship of the Japan Society for the Promotion Science and the KEK Laboratory.

David O. Carpenter is Chairman of the Neurobiology Department, Armed Forces Radiobiology Research Institute, Bethesda, Maryland. This Department is involved in research ranging from membrane biophysics and basic mechanisms of synaptic transmission in invertebrates and mammals to the study of experimental head injury in primates, mechanisms of injury to peripheral nerve, mechanisms of radiation effects on the nervous system and mechanisms whereby active components of snake vernom disrupt nervous system function. He is also Professorial Lecturer in the Departments of Physiology and Neurosurgery at the George Washington University School of Medicine. In addition, he functions as Chairman of the Steering Committee of the Section on the Nervous System of The American Physiological Society. Carpenter's research interests are primarily concerned with the study of synaptic transmission, utilizing both electrophysiologic and biochemical techniques. These studies have been performed in both the sea mollusk, *Aplysia* and in cats. Previous areas of investigation include study of neuronal thermosensitivity, the ionic basis of action and resting potentials, the structure of cell water and ions, and spinal cord and brain stem neurophysiology. In 1971, Carpenter was invited to Mexico as Visiting Professor of Physiology, Contro de Investigacion y de Estudios Avanzados del Institute Politecnico Nacional. In 1973 he was Visiting Scientist in the Department of Psychiatry, University of California at Los Angeles.

Huey Wen Huang is Associate Professor of Physics at Rice University, Houston, Texas. He graduated from National Taiwan University and received his Ph.D. from Cornell University. Since 1967 he has served as Research Associate of Physics at Columbia University, Lecturer of Biophysics at Yale University, Assistant Professor of Physics at Southern Illinois University. He has been teaching at Rice University since 1973.

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Takashi Ichiye is Professor of Oceanography at Texas A&M University, College Station, Texas. He received his Ph.D. from the University of Tokyo. Research interests include the dynamics of ocean circulation, nearshore

oceanography and diffusion, and physical processes near and at ocean bottom. In 1977 he participated in the NATO Air-Sea Interaction Program and also was visiting scientist and lecturer at the Institute of Ocean Sciences at Godalming, England, and at the Marine Science Institute of Kiel University and Dutch Meteorological Institute.

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Mitchel Weissbluth, currently on the staff of ONR Tokyo, is Professor of Applied Physics, Stanford University. His research activities included the development of liquid propellant rockets, meson production, linear accelerators for medical use, biological effects of high energy radiation, electron spin resonance in biological molecules, Mossbauer resonance in heme proteins, effects of high magnetic fields on enzymes, theoretical aspects of the action of hemoglobin, acoustic and X-ray absorption in biological material. Weissbluth served with ONR London in 1967-68 and worked at the Weizmann Institute in Israel in 1960-61 under a Fulbright grant. He is a past president of the International Society of Quantum Biology.

Kanji Ono is Professor of Engineering and Applied Science at the University of California, Los Angeles. He graduated from Tokyo Institute of Technology and received his Ph.D. from Northwestern University, Evanston, Illinois. His current research interests include theoretical and experimental study of strengthening mechanisms and phase transformation and acoustic emission and ultrasonic attenuation studies of structural materials. He is engaged in studies of high-strength beta-titanium alloys and several aspects of acoustic emission behavior of materials. Ono has participated in numerous international conferences in Europe, Japan and Latin America and was one of eight U.S. delegates to the U.S.-Japan Seminar on "Defects in Welded Structures." He received the Henry Marion Howe Medal from the American Society for Metals in 1968.

Thomas B. Sheridan is Professor of Engineering and Applied Psychology at Massachusetts Institute of Technology and also directs the Man-Machine Systems Laboratory. He has served as visiting faculty member at the University of California at Berkeley, Stanford University and the Technical University of Delft, Netherlands. His research interests involve mathematical models of human operator and socioeconomic systems, man-computer interaction in supervising robotic systems and technology for group decision-making. Sheridan is a Fellow of the Human Factors Society and in 1977 received their Paul M. Fitts Award for contributions to education.

CONTENTS

partial contents

SYNCHRONTRON RADIATION RESEARCH IN JAPAN
(Notes on A Visit)

H. Winick

GENERAL

I spent four weeks in Japan in May 1978 at the invitation of Professor K. Kohra of the University of Tokyo, Director of the new Photon Factory (PF) project at KEK,* the Japanese National Laboratory for High Energy Physics. My visit was supported by the Japan Society for the Promotion of Science (JSPS).

During my stay I visited five universities [Tokyo, Osaka, Nagoya, Kyoto and Tohoku (Sendai)] and three laboratories [the Institute for Nuclear Science (INS), Tokyo; the Institute for Solid State Physics (ISSP), Tokyo; and KEK, Tsukuba]. I gave seven formal lectures and had numerous discussions with individuals and groups of scientists regarding many aspects of synchrotron radiation research and facilities. I met scientists already involved with synchrotron radiation research at the INS synchrotron and storage ring and many others planning to use the Photon Factory. I visited many university laboratories particularly for X-ray diffraction and UV spectroscopy and photoemission. A list of most of the scientists that I met is attached to this report (Table I).

Research with synchrotron radiation began in Japan in 1963 on the University of Tokyo's 1.3 GeV synchrotron at the INS. Recently a 400 MeV dedicated storage ring has been put into operation at the same location. All together there are about 12 groups using these facilities. A list of some of these groups and their activities is attached to this report (Table II).

The future of synchrotron radiation research in Japan is very bright because of the start of construction of the Photon Factory project in 1977-78. This is a 2.5 GeV storage ring dedicated to synchrotron radiation research and now in construction. It is scheduled to begin operation for experiments by 1982.

I was quite impressed with the unanimous support for the Photon Factory project by the many scientists I met. Perhaps this is due to the wide dissemination of information about the project during the six years it took to get authorization. Some large projects (e.g., the 12 GeV proton synchrotron at KEK) take even longer to be authorized. There was concern by several scientists that I met about such long waiting periods. The excellent communications among scientists regarding the Photon Factory project continues now with review articles and symposia about various specialized research applications of synchrotron radiation and instrumentation.

There is much awareness of the industrial applications of synchrotron radiation, particularly to X-ray lithography. Many discussions have been held about industrial use of Japanese synchrotron radiation sources but I believe that no clear mechanism for industrial use has yet been worked out. I was told that the Nippon Telephone and Telegraph Corporation is building a conventional X-ray generator to be used for fabrication of integrated circuits.

I learned about two other small storage rings that have been proposed as dedicated synchrotron radiation sources. A 600 MeV machine is proposed by the ETL Laboratory for lithography and standards and calibration work and a 200-300 MeV ring has been proposed by the National Institute for Molecular Science (Banshi Ken) in

*KEK comes from the romanized Japanese name for *K*oh *E*nerugiibutsurigaku *K*enkyusho.

Okazaki. There is also a suggestion that a small storage ring should be built in Sendai, perhaps using an existing 300 MeV linac as an injector.

INSTITUTE FOR NUCLEAR SCIENCE (INS), TANASHI, TOKYO

I spent three days at the INS visiting the 1.3 GeV electron synchrotron and the 400 MeV storage ring and talking with many scientists there. The synchrotron now has one beam channel in use for synchrotron radiation, the second channel having been converted into an injection line for the storage ring. With a maximum critical energy of 1.2 KeV this machine provides good flux for VUV and soft X-ray work but is inadequate for X-ray diffraction and absorption at photon energies above about 5 KeV. I was told that it is likely that the synchrotron would close down in five to six years when the Photon Factory is in full operation. The nuclear and high energy physics programs could transfer to the 2.5 GeV electron linac that is the injector for the Photon Factory.

The 400 MeV storage ring operates up to 360-380 MeV and stores currents above 200 mA although the beam size is large and lifetime is short at the higher currents. During the past year three additional beam lines have been added, bringing the total to four beam lines each with one experimental station. The user community seems to be growing rapidly. The machine runs five days per week, 10 or more hours per day.

The ring is filled at a 1 pps rate at 300 MeV from the synchrotron and about 1 mA is captured per pulse. Personnel are evacuated during injection but work freely around the ring when beam is stored.

The storage ring is an ISSP laboratory separate from the synchrotron. The Director is H. Kanzaki of ISSP. A list of the parameters of this machine is attached to this report (Table III).

Beam Line I is equipped with a 1 m vertically dispersing Seya-Namioka monochromator made by the Kohzu Company. This instrument is located on a second floor level above the ring.

Beam Line II is equipped with a grazing incidence monochromator with a modified Rowland mounting and vertical dispersion. Slits can be varied from 10 μm to 1 mm. This device operates between 70 and 300 Å.

Beam Line III uses "White" radiation with no monochromator for applications such as soft X-ray lithography.

Beam Line IV is equipped with a Nikon grazing incidence horizontally dispersing monochromator operating between 30 and 400 Å.

All beam lines are equipped with two stage differential pumping systems, vacuum sensors and automatic valves. There have been no vacuum accidents. The machine can accommodate about three more beam lines, although working space around the ring is quite limited. There is good coverage by an overhead crane.

A superconducting vertical wiggler (i.e., horizontal magnetic field) is under construction for the Photon Factory and may be tested in the 400 MeV storage ring. There are also plans to try argon discharge cleaning to improve the storage ring vacuum.

PHOTON FACTORY PROJECT

The Photon Factory received partial authorization in April 1977 (the start of the fiscal year in Japan) and full authorization in April 1978. Under construction is the 2.5 GeV storage ring and 2.5 GeV linac injector. This powerful, full energy injector was chosen because it is also planned to use it for several other future purposes

such as a nuclear physics program and as an injector to other storage rings, particularly Tristan (a high energy electron, positron, proton colliding beam complex). Parameters and other information about the Photon Factory are given in the appendix.

Professor K. Kohra, a well known X-ray diffractionist from the University of Tokyo is the Director of the Photon Factory project and currently divides his time between KEK and the University of Tokyo. He will become a Deputy Director at KEK in about three years. The Director of KEK is T. Nishikawa, a high energy physicist who is also quite knowledgeable about synchrotron radiation. For example, he wrote an article on the use of wigglers in 1971.

Professor K. Fuke is in charge of the design of the storage ring and its facilities. He is currently Director of the INS 1.3 GeV synchrotron and now divides his time between KEK and INS. The design staff of the Photon Factory is growing and is now made up of scientists from INS, KEK and other institutions.

There is a Steering Committee for the Photon Factory. Several of its members are indicated on the list of scientists I met which is attached to this report (Table I). A users group has been formed with S. Ebashi of the University of Tokyo (a specialist in X-ray diffraction on biological materials) as Chairman. He is also a member of the Steering Committee.

M. Kihara, one of the few full time machine physicists working on the Photon Factory, visited Stanford and BNL during July 1978. Early this year I. Sato, a member of the 2.5 GeV linac group, visited SLAC.

There is considerable interest to send other scientists to the United States particularly Stanford, to gain experience in synchrotron radiation research, instrumentation, storage ring design, etc.

In the first stage of the Photon Factory it is planned to implement six beam channels with a total of about 17 experimental stations. Originally it was hoped that more experimental facilities could be provided but this part of the budget was cut back. More information on the experimental facilities planned is given in the appendix.

The total budget for all facilities (linac, storage ring, beam lines, experimental stations, buildings, roads, but *not* salaries) is ¥16 x 10^9 which at the current rate of exchange is about \$70 x 10^6. Roughly half of this amount is for the linac and its tunnel and building. I was told that the cost of buildings is very high because of severe earthquake standards. For example, the 450 m long linac tunnel and klystron gallery building costs about ¥4 x 10^9.

When completed in about four years it is planned to have a staff of 130-160 associated with the project with roughly 1/3 research scientists and machine physicists, 1/3 engineers and technicians and 1/3 administrative and miscellaneous. There may be a large number of machine physicists because of the need to train electron storage ring experts for the Tristan project.

Many of the machine physicists will come from the present KEK staff which, judging from the quality of design and construction of the 12 GeV proton synchrotron, is probably very good. There is a very considerable accelerator physics activity in Japan. Interested readers are referred to the Proceedings (in English) of the Second Symposium on Accelerator Science and Technology held at INS, March 23-25, 1978, Y. Hirao, editor. I believe a copy can be obtained by writing him at INS, University of Tokyo, Tanashi, Tokyo, Japan.

The lattice of the Photon Factory is conservative and does not attempt to achieve very low emittance. The field in the bending magnets is only 10 KG at 2.5 GeV. All systems are being designed so that operation at 3 GeV will also be possible. There are 10 straight sections all greater than about 3 m. It is planned to equip one of these with a 3 pole superconducting vertical wiggler to produce a vertically polarized beam for diffraction and

other uses. The wiggler may have only 10 mm horizontal aperture for the beam and will be moved into position after the beam is stored.

The linac will be equipped with take-off points at 500 MeV and 1 GeV so that smaller specialized storage rings could be put there in the future. It is also planned to install a high current front end, in parallel with the normal linac front end, for a position source for Tristan. The linac will have a 50 pps repetition rate but it is planned to use only one pps for injection into the Photon Factory. With an anticipated 5 mA accepted per pulse only 100 sec would be required to reach the 500 mA design current, thus leaving 49 pps for other uses at all times. It is planned to minimize interaction of the injected beam with the rf cavities by mechanical adjustment of tuners on the cavities between injection pulses.

The rf frequency is 500 MHz and a klystron is now in development by a Japanese manufacturer. If there are any delays in the availability of this tube in Japan they plan to use the tubes developed (e.g., by Varian) for DESY. With this high frequency they will have a very short bunch ($< .2$ nsec) and they plan to have the capability to run in one bunch mode for timing experiments. They are quite aware of the problem of higher mode (or parasitic) losses due to high single bunch currents and are taking care to design the vacuum system to minimize these effects. Curiously, it could be the many slots in vacuum chamber that are needed to allow radiation to exit, that set the current limit in a machine with high rf frequency. There was considerable interest in the use of large angle UV ports for fluorescence lifetime measurements such as those which have been recently done by Stryer and Munro at SSRL.

A major technical problem in a multi-beam synchrotron radiation facility such as the Photon Factory is the steering of many tangential photon beams. The requirements are very severe (typically $\pm$ 1 mm at 10 or 20m). Much thought is being given to orbit control of the electron beam and position monitors and controls for the synchrotron radiation beams.

My overall impression is that the Photon Factory is an excellent project, well underway and well conceived. For example, full prototypes of the bending magnet and rf cavity have been built and are under test. Although there is not much experience with electron storage rings in Japan,* there are many accelerator physicists at INS, KEK and elsewhere with experience in the basic accelerator technologies.

Much thought has been given to future developments stemming from the Photon Factory. There is room for many (perhaps 20) additional beam lines after the initial six. There are many long straight sections for future insertions. The linac has the capability of serving many other purposes as mentioned earlier. The high energy physics community seems solidly behind the Photon Factory because of its intrinsic merits and because it provides the basic electron storage ring experience and a powerful electron linac, both of which are important ingredients for future high energy physics developments, particularly Tristan.

The KEK laboratory is located in Tsukuba, a new academic city about 100 km from Tokyo. Starting in about 1968 governmental laboratories and agencies have moved there. Today there are more than 40 institutions there including the University of Tsukuba, the National Institute for Research in Inorganic Materials, the Research Institute for Polymers and Textiles, the National Research Institute for Metals, etc.

*The 400 MeV ring at INS was designed by Sasaki and his group who are experimentalists, not machine physicists, and they are not much involved in the basic design of the Photon Factory ring. They are involved in the design of the beam channels and instrumentation.

TABLE I

SCIENTISTS AUTHOR MET ON VISIT TO JAPAN

NAME	*AFFILIATION*	*REMARKS*
M. Ando	University of Tokyo	P.F.[+] experimental facilities
H. Aridome	Osaka University	X-ray diffraction
T. Fukamachi	Saitama Institute of Technology and ISSP	X-ray diffraction, absorption
J. Harada	Nagoya University	Solid state physics
S. Homma	INS	High energy physics
*G. Horikoshi	KEK	P.F. vacuum
S. Hosoya	ISSP	X-ray diffraction, absorption
*K. Fuke	University of Tokyo, KEK	In charge of Design of Photon Factory; Director of INS 1.3 GeV synchrotron
T. Ishii	Tohoku University, ISSP	Instrumentation for INS-SOR ring
R. Kajikawa	Nagoya University	High energy physics
N. Kajiura	KEK	P.F. controls
A. Kakizaki	Miyagi University	P.F. experimental facilities
H. Kanzaki	University of Tokyo, ISSP	Director of INS-SOR 400 MeV
S. Kasagi	JSPS	Executive Director
*N. Kato	Nagoya University	X-ray diffraction
T. Katsura	KEK	P.F. controls
T. Kawamura	Yamanashi University; ISSP	X-ray diffraction; absorption
M. Kihara	KEK	P.F. lattice
H. Kitamura	ISSP	Vacuum for INS-SOR, wiggler
S. Kiyono	Tohoku University, ISSP	X-ray absorption
*K. Kohra	University of Tokyo, KEK	Director, Photon Factory; X-ray diffraction
*H. Kuroda	University of Tokyo	P.F. experimental facilities
T. Matsushita	University of Tokyo	P.F. experimental facilities
*T. Mitsui	Osaka University	Biophysics
K. Miyake	Kyoto University	High energy physics
Y. Nakai	Kyoto University	Solid state physics
*S. Namba	Osaka University	X-ray lithography
T. Nishikawa	KEK	Director of KEK
T. Ohta	University of Tokyo	P.F. experimental facilities
*T. Sagawa	Tohoku University	VUV spectroscopy
*T. Sasaki	University of Tokyo, ISSP	VUV spectroscopy
I. Sato	ISSP	P.F. beam line design
O. Shimoura	National Institute for Inorganic Material Research and ISSP	X-ray diffraction, absorption
S. Suga	University of Tokyo, ISSP	Responsible for operation of INS-SOR 400 MeV ring
T. Sugano	University of Tokyo	P.F. experimental facilities
F. Sugawara	ETL, Tokyo	Proposing 600 MeV ring for calibration and lithography
H. Sugawara	Tohoku University	Instrumentation for INS-SOR ring
S. Suzuki	Tohoku University, ISSP	VUV spectroscopy
K. Takata	KEK	P.F. rf
Y. Uchikawa	Nagoya University	X-ray diffraction

TABLE 1 (*continued*)

SCIENTISTS AUTHOR MET ON VISIT TO JAPAN

NAME	*AFFILIATION*	*REMARKS*
T. Ueki	Osaka University	X-ray diffraction
M. Watanabe	ISSP	P.F. experimental facilities
T. Watanabe	Tohoku University	Solid state physics
Y. Yamada	Osaka University	Solid state physics
T. Yamakawa	INS, KEK	Machine physics, magnets, wigglers

*Member – Steering Committee of Photon Factory
+P.F. = Photon Factory

TABLE II

EXPERIMENTS WITH THE ELECTRON SYNCHROTRON

1. Soft X-Ray Small-Angle Scattering by Polystylene Latexes Using Synchrotron Radiation

   A. Kakizaki,* K. Wakabayashi+, *Y. Sioia*, K. Namba+, K. Kurita++, M. Yokota, H. Tagawa++, Y. Inoko+, *T. Mitsui*+, E. Wada++, T Ueki+, I. Nagakura+++ and T. Matsukawa+++ (Research Institute for Science Education, Miyagi Univ. of Education, Sendai, +Faculty of Engineering Science, Osaka Univ., Osaka, ++College of Science and Technology, Nihon Univ., Tokyo, +++Faculty of Education, Gunma Univ., Maebashi, +++College of General Education, Osaka Univ., Osaka)

2. X-Ray Lithography by Synchrotron Radiation of INS-ES

   H. Aritome, S. Matsui, K. Moriwaki, A. Hasegawa, and S. Namba (Faculty of Engineering Science, Osaka University)

3. Soft X-Ray κ-Spectra of Light Elements with Fluorescent Excitation Using Synchrotron Radiation

   K. Tsutsumi, O. Aita and K. Ichikawa (Univ. of Osaka Prefecture), H. Nakamura (Osaka Electro-Communication Univ.)

4. Focusing of Synchrotron Radiation in the Soft X-Ray Region

   S. Aoki, S. Kawada and Y. Sakayanagi (Institute for Optical Research, Tokyo Kyoiku Univ.)

5. Absorption and Excitation Spectra of Polymer Thin Films in the Carbon K Edge Region

   S. Suga, K. Inoue, A. Uchida, A. Mikuni, H. Kitamura and *H. Kanzaki* (the Institute of Solid State Physics, The Univ. of Tokyo)

6. Absolute Measurements of Synchrotron Radiation (SOR)

   T. Oshio, Y. Matsukawa, H. Sonoda (Osaka City Univ.), M. Otsuka, K. Sato, M. Ueda (Nagoya Univ.), M. Shiho (Univ. of Tokyo), M. Suzuki, M. Habu, T. Nagasaka, M. Nishi, F. Sugawara, H. Onuki, K. Sakihara (Electrotechnical Lab.) and T. Katoh (Nippon Dental Univ.)

TABLE II (*continued*)

EXPERIMENTS WITH THE 400 MeV ELECTRON STORAGE RING (SOR-RING)

1. Absorption and Reflection Measurements of Alkali Halides and Cuprous Halides in the Extreme Ultraviolet Region

   M. Watanabe and K. Nishioka (Univ. of Tokyo)

2. Absorption Measurements of Alkali Metals in the Vacuum Ultraviolet Region

   S. Sato (Univ. of Tokyo), T. Miyahara (Tokyo Metropolitan Univ.), T. Ishii* (Univ. of Tokyo) and S. Yamaguchi (Tokyo Metropolitan Univ.)
   *Guest staff at the Institute for Solid State Physics from Tohoku Univ.

3. Modulation Spectroscopy of KDP in the Vacuum UV Region

   R. Onaka, M. Kita, H. Takahashi and H. Abe (Institute for Optical Research, Tokyo Kyoiku Univ.) and S. Saito (Faculty of Engineering, Meiji Univ.)

4. Experimental Setup

   T. Ito, K. Kobayashi (Univ. of Tokyo), Y. Hatano, K. Ito, A Yokoyama (Tokyo Inst. of Tech.), and K. Hieda (Rikkyo Univ.)

5. Some Characteristics of SOR

   T. Ito and K. Kobayashi (Univ. of Tokyo)

TABLE III

PARAMETERS OF THE SOR-RING (Status December 1977)

Energy of stored electrons			250 ~ 400 MeV
Highest current stored at 307 MeV			330 mA (10^{11} el.)
Initial current in normal operation			200 ~ 300 mA
Typical beam life at 307 MeV for	200 mA 100 mA	(τ in exp[$-t/\tau$])	47 min. 71 min.
Radius of a bending magnet (BM)			1.10 m
Field strength of BM			7.6 ~ 11.5 kG
Field index of BM			n = 0.4
Total orbit length			17.4 m
Revolution frequency			17.26 MHz
Resonant frequency of the RF cavity			120.82 MHz
Operating RF voltage			15 kV
Radiation loss of an electron per turn			0.65 keV
Number of betatron oscillations*			$\nu_x = 1.28$, $\nu_z = 1.21$
Values of field gradient of a QM*			$K_F = 6.3$m, $K_p = 6.1$m

TABLE III (*continued*)

PARAMETERS OF THE SOR-RING (Status December 1977)

Source parameters*	σ_x, $\sigma_{x'}$	$\triangleq$ 0.8mm, 0.27mrad
	σ_z, $\sigma_{z'}$	$<$ 0.2mm, 0.08mrad
Dilation factor		$\alpha_c \triangleq 0.58$
Damping time of betatron oscillations		τ_x, $\tau_z \triangleq$ 54msec.
Average pressure in vacuum chambers	without beam	$< 7 \times 10^{-10}$ Torr
	with 100mA beam	$< 5 \times 10^{-9}$ Torr
Total design pumping speed		$>$ 4500 l/sec
Frequency of injection		1 Hz
Typical filling time		5 min.
Useful range of photon energy	300 MeV	$<$ 0.44 keV
	400 MeV	$<$ 1.0 keV

*Under the normal mode of operation.

APPENDIX*

OUTLINE OF PHOTON FACTORY PROJECT
July 1978

The 1.3 GeV electron synchrotron of the Institute for Nuclear Study (INS), University of Tokyo, began to be used for high-energy physics experiments in the middle of 1962. Immediately after its first successful operation, a group of solid-state physicists proposed to use radiations from the above synchrotron (INS-ES), for spectroscopic studies of atoms, molecules and solids. This group, called the INS-SOR group, started their experiments at INS-ES from 1964 and obtained a number of brilliant results demonstrating the great use of synchrotron radiation in XUV spectroscopy. The two beam channels constructed at INS-ES had been the only available facilities of synchrotron radiation in Japan for about 10 years. In the meantime, the INS-SOR group proposed to construct a 300 MeV storage ring, dedicated for the use of synchrotron radiation, in order to fill the increasing demands for SOR experimental facilities. This proposal was authorized in 1971, and the construction of the machine at INS was completed in 1974. The operation of this storage ring was started in the spring of 1975, and a SOR research laboratory was established in the Institute for Solid-State Physics, University of Tokyo, in April of the same year.

On the other hand, scientists in the field of crystallography had been looking for a powerful X-ray source. In 1969 they organized a study group for an extremely strong X-ray source. In 1971 they reached the conclusion that synchrotron radiation will be the best solution for their demands, and contacted the INS accelerator group to investigate the possibility of constructing a several GeV storage ring which can generate intense radiations in the hard X-ray region. At that time the high-energy division of INS was intending to renew the 15-year old electron synchrotron. Thus the crystallography group and the INS high-energy group joined to promote the construction of a high-energy electron synchrotron and storage ring. They then realized that the intense synchrotron radiation from such a storage ring, covering the region from XUV to hard X-ray, had unexpectedly wide applications, and that a large number of scientists in different fields would also strongly wish to use such synchrotron radiation. Thus they invited scientists of other fields in physics, chemistry, biology and engineering sciences to join their project.

The project mentioned above was named "Photon Factory Project." An informal working group for this project started its activity in the spring of 1973 and prepared the first draft of a proposal. In the autumn of 1974 the Science Council of Japan advised the Government to establish a new research institute for the application of synchrotron radiation, and a committee concerned with this project was formed in the Science Council in the beginning of 1975. At the same time scientists interested in this project organized the "Photon Factory Community" to promote the project. Hitherto about 300 scientists have joined this organization.

The executive committee of the Photon Factory Community consisted of the following four members: K. Kohra, Chairman (Professor, Faculty of Medicine, University of Tokyo), K. Huke (Professor, INS, University of Tokyo) and H. Kuroda (Professor, Faculty of Science, University of Tokyo). The committee investigated various problems concerned with the establishment of the Photon Factory and finally reached the conclusion that it would be best to establish the Photon Factory as an experimental facility within the Institute of High-Energy Physics (KEK) in the Tsukuba area, not as an independent research institute as it was first proposed.

The conclusion was accepted by the Photon Factory Community as well as by the committee in the Science Council of Japan. The negotiations between KEK and the Photon Factory Community culminated in success, and a special committee consisting of the four members of the executive committee of the Photon

*This Appendix is based on information provided to Professor M. Weissbluth by K. Kohra (Director of the Photon Factory (PF) of KEK and Professor, Department of Applied Physics, Faculty of Engineering, University of Tokyo) and by H. Kuroda (Professor of PF of KEK and Professor, Department of Chemistry, Faculty of Science, University of Tokyo). The information was developed from material originally prepared by H. Kuroda for presentation at a seminar at Stanford University in 1977.

Factory Community and several staff members of KEK was formed in KEK to prepare the proposal for the Photon Factory.

In the 1977 fiscal year, the Government approved the budget for the preliminary investigation of the construction of the Photon Factory (PF) in KEK.

The committee for this investigation started in March 1977. The chairman of the committee was H. Kuroda. According to the results of the investigation of the above committee, the final plan of Photon Factory was submitted to the Government through KEK and was finally approved by the Government at the beginning of 1978.

The construction of Photon Factory started in April 1978 and is expected to be finished in 1982. K. Kohra has been appointed as the director of Photon Factory for the term of 1978-1984. A committee to decide policies concerned with the construction, operation and appointment of staff members of the Photon Factory was formed in KEK; it consisted of outside scientists and in-house staff members, their total number being twenty. H. Kuroda has been appointed as the chairman of the Photon Factory Committee for the term 1978-1981.

A chronological description of the progress of the Photon Factory project is listed in Table 1. The construction schedule of the Photon Factory is shown in Figure 1 and the construction cost is listed in Table 2.

SITE OF PHOTON FACTORY

The Photon Factory will be constructed within KEK in the Tsukuba area which is located about 100 km north of Tokyo. In KEK the 8 GeV proton synchrotron has been constructed and is now being operated for high-energy experiments. KEK also has a future project called "TRISTAN" (Tri-Ring Intersecting Storage Accelerators in Nippon), which consists of rings for storing 18 GeV electrons and positrons and also two beams of 180 GeV protons and carries out colliding beams experiments on $e^- + e^+$, $e^- + p$ and $p + p$. By taking into account this future project of KEK, the locations of the accelerators and buildings of the Photon Factory have been decided as shown in Figure 2. A more detailed Layout of the Photon Factory facility is shown in Figure 3.

ACCELERATORS

The accelerators which will be constructed in the Photon Factory consist of two parts: a 2.5 GeV linac as an high-energy electron source, and a 2.5 GeV storage ring fully dedicated for synchrotron radiation experiments.

The following scientists are now working in KEK for the construction of Photon Factory:

K. Kohra (Professor, PF, KEK and Professor, University of Tokyo) (Director, Exp. Apparatus)
J. Tanaka (Professor, Accelerator Division, KEK) (Linac)
I. Sato (Professor, PF, KEK) (Linac)
K. Fuke (Professor, INS, University of Tokyo and Visiting Professor, PF, KEK) (Storage Ring)
M. Kihara (Professor, PF, KEK) (Storage Ring)
T. Tamakawa (Associate Professor, University of Tokyo)
H. Kuroda (Professor, University of Tokyo and Visiting Professor, PF, KEK) (Exp. Apparatus)
S. Kikuta (Associate Professor, University of Tokyo) (Exp. Apparatus)
M. Ando (PF, KEK) (Exp. Apparatus)
T. Ohta (University of Tokyo) (Exp. Apparatus)

Other than the above scientists, more than ten scientists, either from KEK or universities, are working in collaboration with the above people.

LINAC

The 2.5 GeV LINAC consists of the electron gun, the accelerator and the beam switchyard. The accelerator is composed of 160 units of microwave guides, each of which has a length of 2 m. Accordingly, the total length of the LINAC will be about 400 m.

The LINAC will be constructed to be half underground; the klystrons and electric power supplies are above ground, while the accelerator and the electron gun are underground.

The electrons of 2.5 GeV energy are injected into the storage ring through the beam switchyard. The electrons with energies less than 2.5 GeV can also be taken out from the intermediate portions of the accelerator.

Two take-out ports, at 1.0 GeV and 0.4 GeV, respectively, will be constructed in order to prepare for the construction of low-energy storage rings in the future. This LINAC can be used also as the injector of electrons and positrons when the TRISTAN ring is constructed. Some parameters of the LINAC are listed in Table 3.

STORAGE RING

The storage ring of the Photon Factory has a prolate-like lattice structure in which the short diameter is 50 m, and the long diameter is 60 m, as shown in Figure 4. It consists of 28 units of bending magnets with a curvature of 8.33 m, 58 units of quadrupole magnets and two RF cavities, whose total power is 1.2 MW.

The unique feature of this lattice design is that it has two kinds of straight sections; two long sections and eight sections of medium length, whose lengths are 5.0* m and 3.54 m, respectively.

Two RF cavities and an injecting septum magnet are inserted in the medium straight sections. The remaining five sections are reserved for wigglers and RF cavities.

In the first stage only one of the straight sections will be used for the vertical wiggler, which consists of 3-pole 6-Tesla magnets with superconducting coils in the vertical plane, as shown in Figure 5. This wiggler has a curvature of 1.39 m and provides very intense hard X-rays of vertical polarization.

The long straight sections are prepared for future developments such as a helical wiggler.

Principal parameters of this storage ring are listed in Table 4.

EXPERIMENTAL FACILITIES FOR SYNCHROTRON RADIATION

In principle, 19 beam channels for synchrotron radiation can be constructed around the storage ring. However, we decided to construct six beam channels in the first stage; one is the wiggler for extremely hard X-ray region, three for hard X-ray, and two for the XUV-SX regions. The remaining positions are reserved for future expansion. The beam taken out at each beam channel is divided into four or five beam lines by beam splitters in the case of the XUV-SX channel and by crystal monochromators in the case of the HX channel. The overhead view of the experimental facilities around the storage ring is shown in Figure 6. The monochromators which will be placed at each beam line, and the type of experiments to be carried out there, are listed in Table 5. A sketch of the Photon Factory facility is shown in Figure 7.

*The long straight section can be extended up to 7 m by removing the quadrupole magnets, if it is necessary.

TABLE 1

THE PROGRESS OF PHOTON FACTORY PROJECT

1969	Study group on high-power X-ray source (Scientists in the field of X-ray crystallography)
1970-1972	Discussion on the possibility of constructing a high-energy storage ring for synchrotron radiation
1973	First draft of Photon Factory Project (PF working group)
1974	Recommendation of the promotion of Photon Factory Project (Science Council of Japan)
1975	Photon Factory Community
1976	Special Committee for Photon Factory Project (KEK)
1977	Government approved the budget for the preliminary studies for the construction of Photon Factory in KEK Study Committee for Photon Factory (KEK) Final proposal to the Government
1978	Construction is started in KEK

TABLE 2

CONSTRUCTION COST

Building	4.48 x 10^9 ¥
Cooling/Air Conditioning	2.10
Electrical	1.79
Linac	3.75
Storage Ring	
Magnet	0.46
RF	0.55
Vacuum	0.33
Transport	0.14
Control	0.64
Beam Lines	0.20
Experimental Facilities (First Phase)	1.00
	15.44 x 10^9 ¥

TABLE 3

PRINCIPAL PARAMETERS OF THE LINAC

General	
Max. energy loaded (50 mA)	$\geq$ 2.5 GeV
Peak beam current	$\geq$ 50 mA
Repetition rate	$<$ 50 Hz
Beam width	$>$ 1.0 μsec
Average current	2.5 μA
Energy spread	$\pm$ 0.5%
Emittance	$2\pi \times 10^{-8}$ m $\cdot$ rad
Accelerating guide	
Type of acc. structure	TW, Constant gradient
Operating frequency	2856 MHz
Type of mode	$2\pi/3$
Length of unit guide	2 m
Number of guides	160
Filling time	0.5 μsec
RF power	
Klystron peak power	$\geq$ 20 MW
Number of Klystrons	40
Pulse width	3.0 μsec
Total power	1 MW

TABLE 4

PRINCIPAL PARAMETERS OF THE STORAGE RING

General		
Energy		2.5 Gev (max. 3.0 GeV)
Max. stored current		500 mA (1.86 x 10^{12}e)
Peak magnetic field		10 KG
Radius of curvature		8.33 m
Mean orbit radius		29.58 m
Revolution frequency		1.682 MHz
Total power of radiation		208 KW (280 KW with Wiggler)
Magnet and Lattice		
Number of bending magnets		28
Number of quadrupole magnets		58
Number of long straight sections (5m)		2
Number of medium straight sections (3.54m)		8
Number of normal cells		14
Focusing order in normal cell		FODO
Betatron number		5.25-9.25 (Horizontal) 5.25 (Vertical)
Length of Bending magnet		1.87 m
Length of quadrupole magnet		0.5 m
Total magnet power		1.3 MW
RF system		
Frequency		476 MHz
Harmonic number		283
Synchrotron radiation loss		415 KeV/turn
RF voltage		2.4 MV
Number of cavities		2
Total RF power (input)		1.2 MW
Properties of stored beam and SOR		
Average pressure		1 x 10^{-9} Torr
Life time		10 hrs
Injection energy		2.5 GeV
Injection rate		1 Hz
Injection time		10 min (4 times/day)
Energy spread of stored beam		0.07% (1.8 MeV)
Bunch length		~ 15 cm
SOR emittance		0.1 ~ 0.2 πmm · mrad
SOR pulse width		~ 50 psec
Pulse separation	(single bunch mode)	595 nsec
	(283 bunch mode)	2.10 nsec
Wiggler		
Type		3-pole, vertical
Field strength of magnet		60 KG
Radius of curvature		1.39 m
Critical wave length		0.48Å

TABLE 5
SOR EXPERIMENTAL FACILITIES

	Beam Channel SX-I (SX-XUV)	
SI-1	Normal-incidence monochromator (Vertical) (300-1000Å) (high-resolution)	Absorption spectra of gases atoms and molecules
SI-1′	Seya-type (Vertical) 3000-1000Å)	Refelection spectra and emission spectra of solids Photo-emission
SI-2	Grazing-incidence (Vertical) (20-300Å)	Reflectron spectra and photoelectron spectra of solids
SI-3	Crystal monochromator (5-10Å)	XPS
	Beam Channel S-II	
SII-1	Seya-type monochromator (Vertical) (300-1000Å)	Photoionization and photodissociation of gaseous molecules
SII-3	Seya-type monochromator (300-1000Å)	Photochemical studies
SII-3′	INS-SOR type monochromator (200-400Å)	Radiation effects on biological system
SII-2	Grazing-incidence monochromator (20-300Å)	Photoelectron spectra of gases. Radiation effects
SII-4	6 m Photographic spectrometer	Absorption spectra of gases
SII-4′	Grazing incidence (low resolution)	X-ray lithography
	Beam Channel H-I	
HI-1	Point focusing monochromator	Elemental analysis
HII-2	No monochromator (SSD detector)	Structure analysis
HII-3	No monochromator (SSD detector)	Under extreme conditions (low temp. high temp., high pressure)
	Beam Channel H-II	
HII-1	Curved crystal monochromator	Small-angle scattering in solutions
HII-1′	Curved crystal monochromator	Small-angle scattering of biological systems
HII-2	Crystal monochromator	X-ray radiography
HII-3	Crystal monochromator	X-ray diffuse scattering
	Beam Channel H-III	
HIII-1	Special crystal monochromator	Liquid diffraction
HIII-2	Two crystal monochromator	EXAFS
HIII-3	Crystal monochromator (low resolution)	Radiation effects
	Beam Channel W-I	
W-I	High resolution crystal monochromator	X-ray optics; X-ray topography
W-II	Three crystal monochromator	X-ray quantum optics
W-III	Crystal monochromator	Structure analysis of protein crystals
W-IV	No monochromator (SSD detector)	Structure analysis of crystals

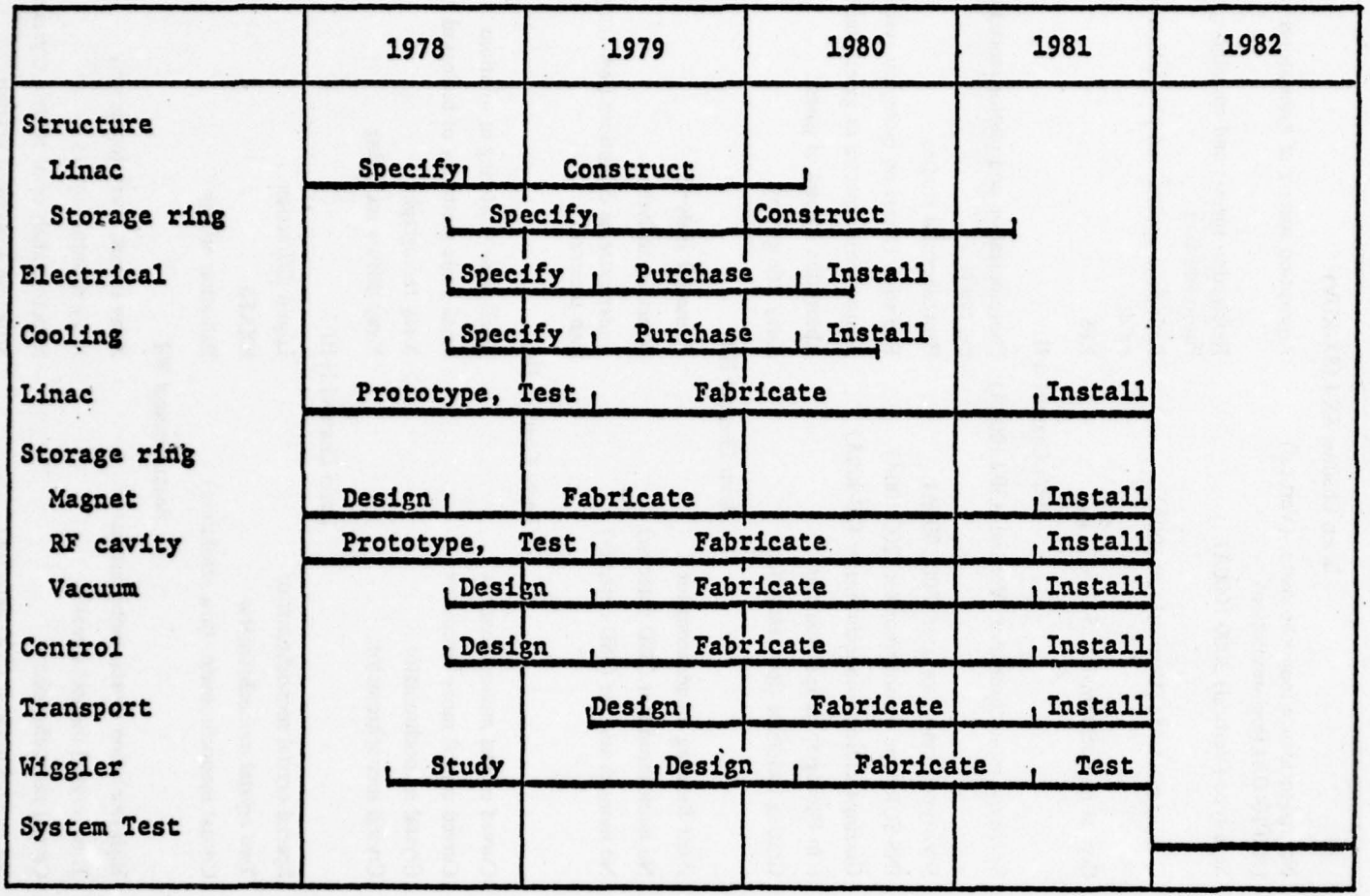

Figure 1. Photon Factory Construction Schedule

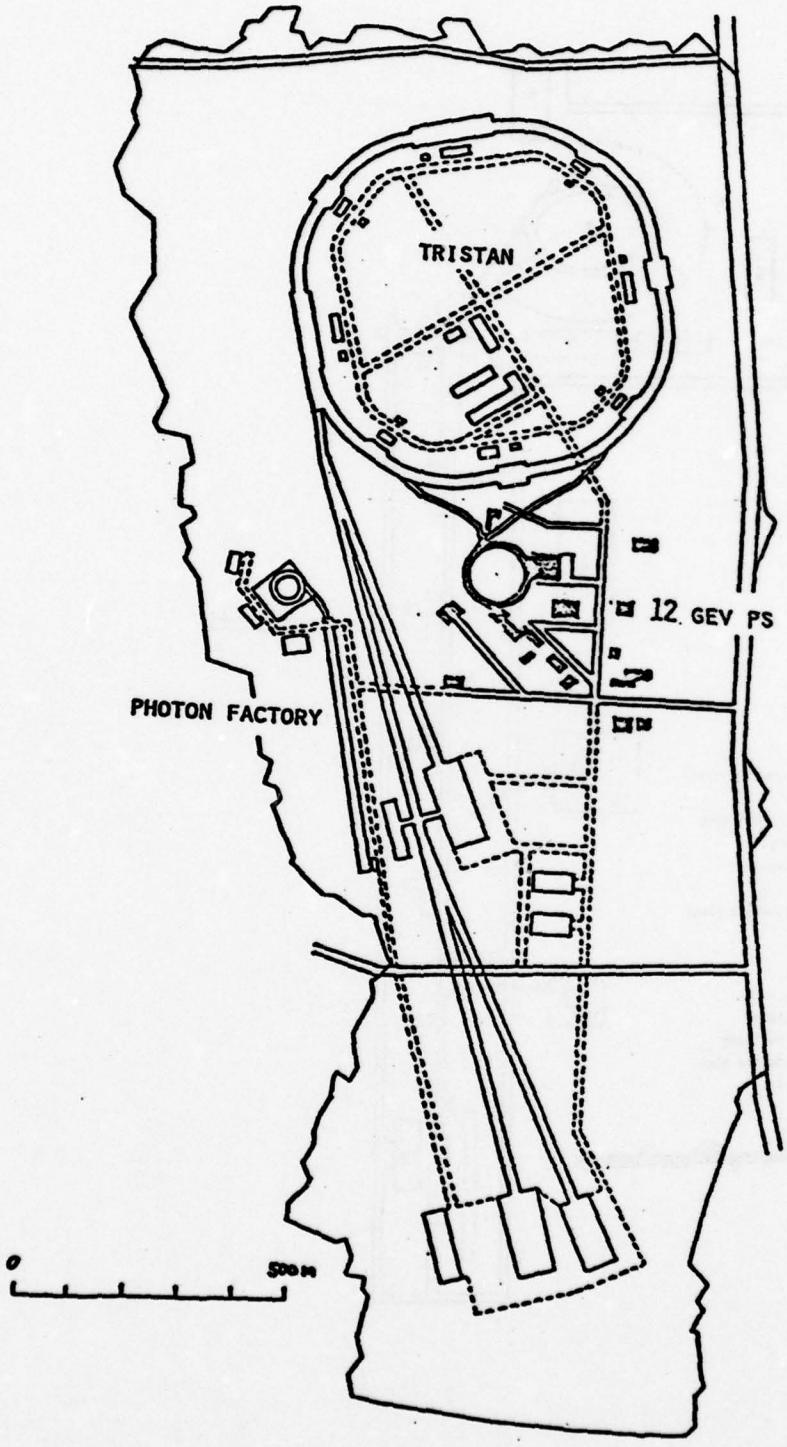

Figure 2. Location of Photon Factory in KEK Site

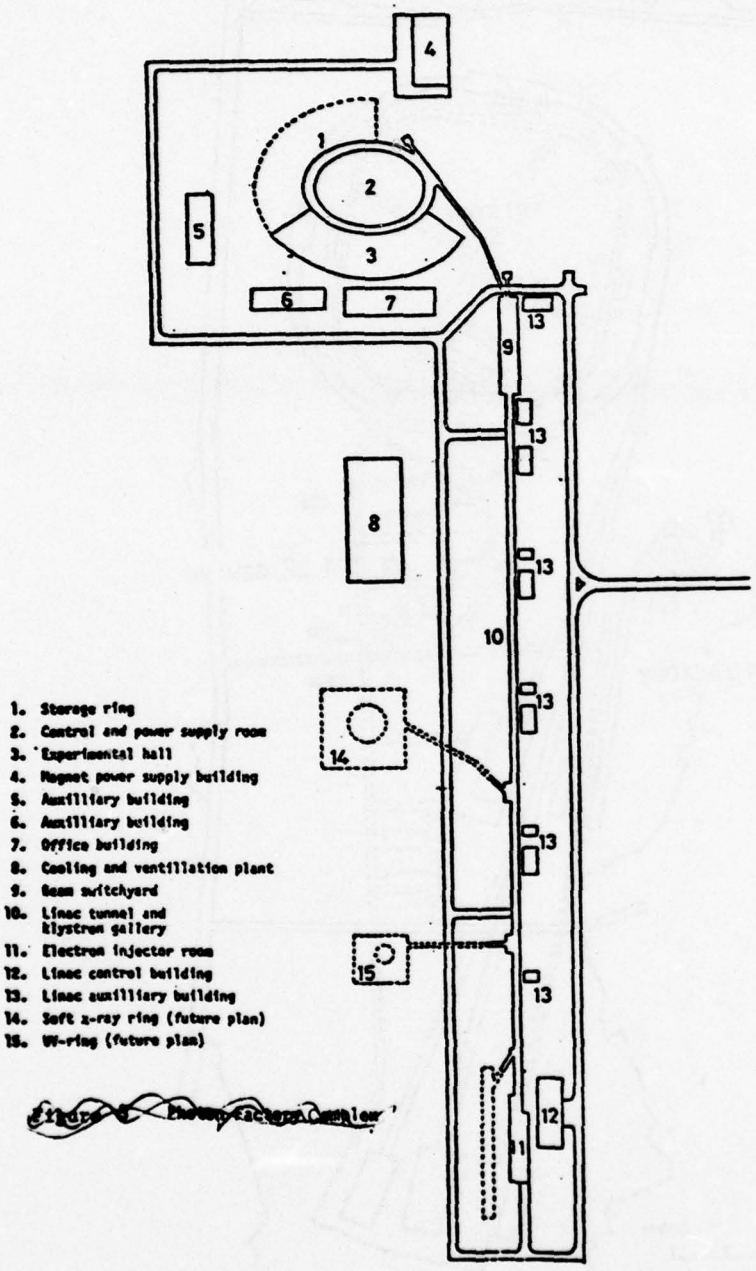

Figure 3. Photon Factory Complex

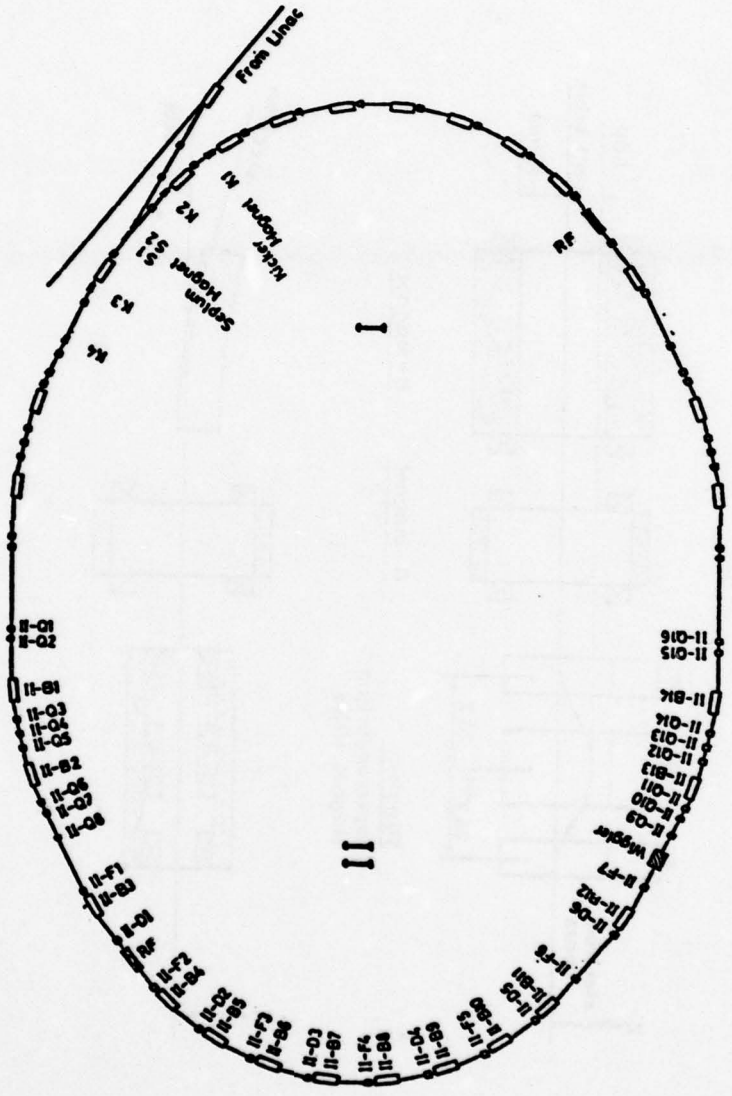

Figure 4. Lattice Structure of the Storage Ring

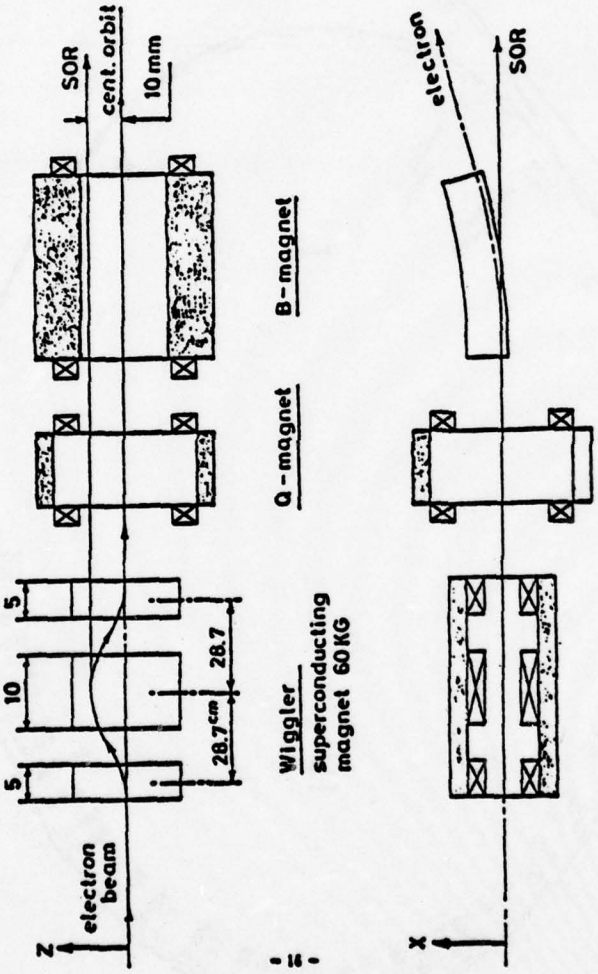

Figure 5. 3-Pole Vertical Wiggler

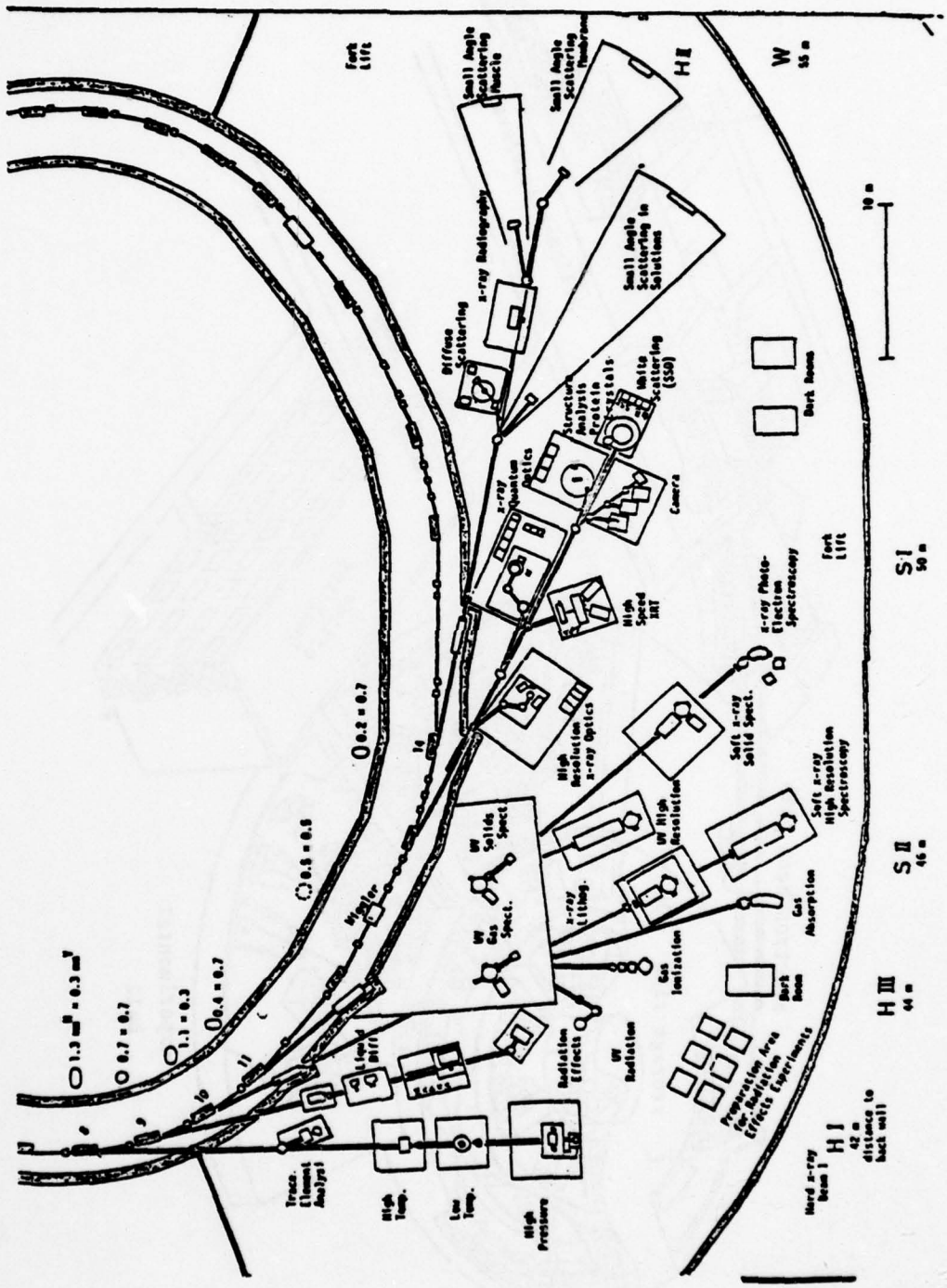

Figure 6. Overhead View of 28 Experimental Stations. Macroview of Photon Factory – 2.5 GeV – KEK

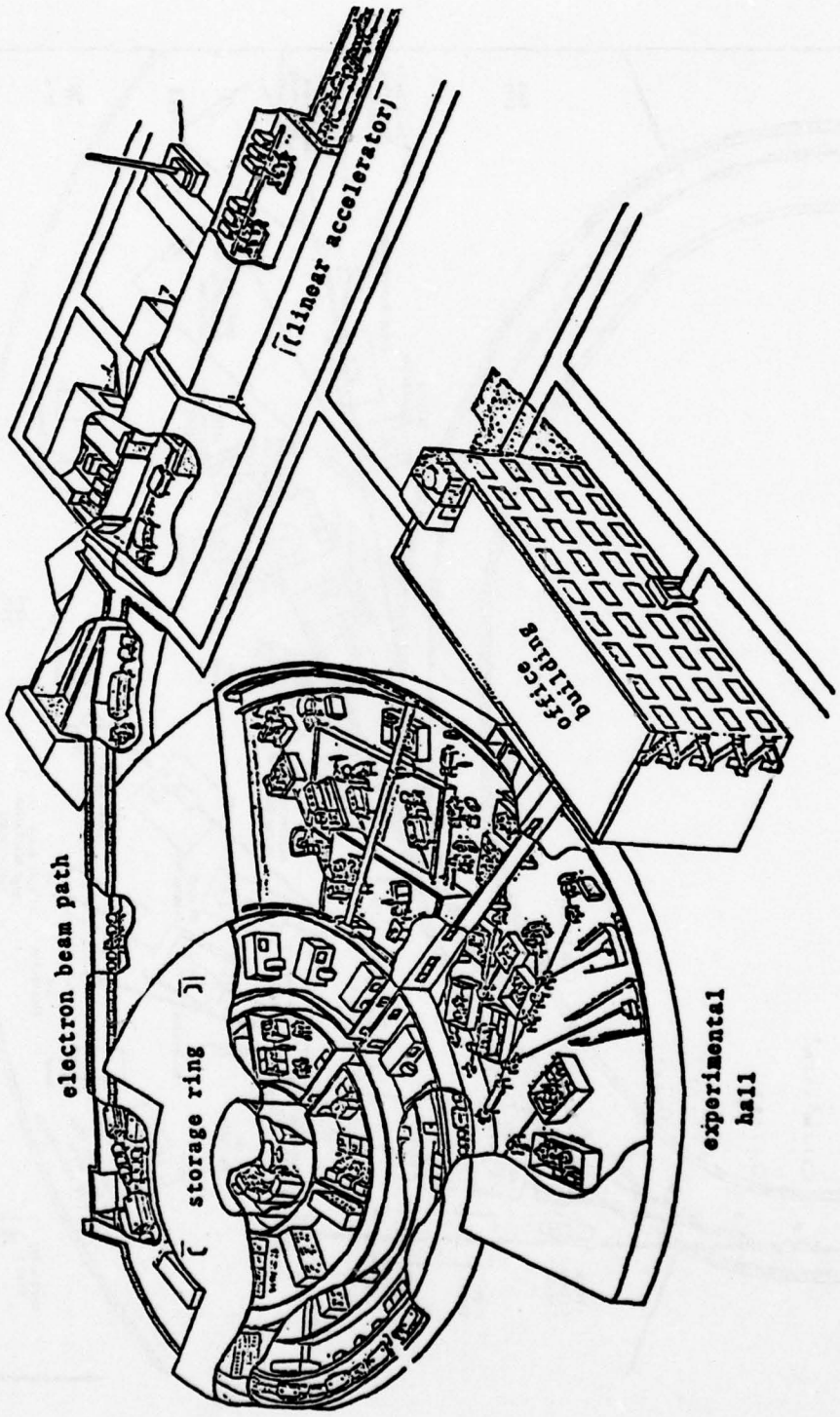

Figure 7. Sketch of the Photon Factory Facility

MEMBRANE BIOPHYSICS AND GENERAL NEUROBIOLOGY IN JAPAN

David O. Carpenter

While on a trip to Japan for two scientific conferences in August and September, 1978, I had the opportunity to visit a number of universities and institutes with research programs in biophysics and neurobiology. This report summarizes my visits and impressions of this field of biomedical science.

In all Japanese universities a department has only one person at the level of professor, one as associate professor, and one as assistant. This organization, I found, yielded rather small research groups by American standards. At many of the Japanese universities it has been necessary to create several departments in order to achieve a balanced research program. Therefore in some schools there are more than one Department of Physiology with interests either related or unrelated.

My first visit was to the Department of Physiology of Shiga University School of Medicine at Ohtsu. This is a new medical school and has just admitted its fourth class. In Japan, as in Europe, medical students enter a six-year program directly from high school, and the first two years are effectively premedical courses. Physiology is taught in the third year. Professor H. Kitasato and Dr. K. Murayama were my hosts at Shiga. Their laboratories are in a lovely, new building at the foot of the mountains and are spacious and well-equipped. Their research interests are on three quite different projects. The first project concerns the effects of insulin on sodium transport in frog skeletal muscle. Insulin is known to increase sodium efflux from muscle but it has not been known how this effect is mediated. Drs. Kitasato and Murayama find that insulin does not change the rate of maximal pump activity but rather shifts the affinity of the pump for sodium.

In another study they are investigating the gating currents in the giant axon of crayfish. Gating currents are very small currents that reflect the opening or closing of the "gate" at ionic channels in excitable tissues such as nerve and muscle. New electronic techniques and pharmacologic methods of blocking the action currents of sodium and potassium have allowed these gating currents to be measured directly. The study on the crayfish axon gating current is a very nice one and has led to results that have significance for other neuronal tissues.

The third project at Shiga is an electrophysiological study on a nonneuronal cell: the beta cell of the pancreas. These cells are electrically excitable and can actually discharge in two forms. One form is a complex pacemaker spike with several peaks, and the other is an abrupt single spike. Membrane potential in these neurons may shift abruptly to different states. The significance of these electrical charges for beta cell function is not known, but its elucidation is the purpose of this study.

My next stop was at one of 19 marine stations in Japan: the Tamano Marine Laboratory of Okayama University, located in Tamano. This laboratory, a part of the Faculty of Science, specializes in the study of photosensitivity in lower animals and embryos of molluscs and fish. The laboratory is headed by Professor M. Yoshida and is particularly interested in anatomic and electron microscopic analysis of single eyes in various lower animals such as the jellyfish, arrow worm, and embryos of squid, barnacles, and fish. It is of special interest that there are a considerable variety of kinds of eye in jellyfish, suggesting that these structures may show several stages in the evoluation of the eyes of higher animals as we know them. In animals such as squid and barnacle, which undergo one or several different metamorphoses in the course of development, there may be totally different kinds of eyes and mechanisms of photodetection at different life stages. This also provides a clue to evolutionary development. Although the station has a permanent staff of only three persons, it has been

remarkably productive and has made contributions in study of the behavior, neurophysiology, and biochemistry as well as anatomy of photosensitive machanisms.

My next visit was to another relatively new private medical school, Kawasaki Medical College at Kurashiki, Okayama. One Department of Physiology is headed by Professor M. Matsumura. Dr. Matsumura is a well-trained muscle physiologist who has studied both electrical and mechanical properties of crayfish muscle fibers. He is presently interested in a "tension-clamp" of vertebrate skeletal and heart muscle. Dr. H. Kita also studies aspects of muscle physiology, but is interested particularly in the effects of cooling and replacement of calcium by nickle, cobalt and manganese on the mechanisms of release of neurotransmitter from the nerve terminals innervating the muscle fiber.

The other Department of Physiology, headed by Professor H. Okada, is interested in problems of nervous control of digestion functions such as gastric reflexes, defecation, and gut smooth muscle mobility. Although this is not an area I know well, the studies appear important although difficult. Professor Okada and his associates have found a site in the pons of the brain stem that they believe is important in defecation. The only neural centers previously known to be critical in this process are in sacral spinal cord.

My host and guide during the visit to all laboratories in the Okayama area was Associate Professor Hiroshi Takeuchi of the Institute of Neurochemistry, Okayama University Medical School. Dr. Takeuchi's research utilizes the African land snail, and he studies properties of the isolated brain of this animal. Like many other molluscs, this preparation contains several very large neurons that can be easily identified in every preparation. Not only are these nervous systems easily maintained in isolation from the animal but also the very large size of the identifiable neurons makes relatively easy their penetration with small intracellular microelectrodes. Dr. Takeuchi is interested in the pharmacological sensitivities of these neurons to several substances that may be neurotransmitters (including active small peptides) and to ergot compounds, which have complex excitatory/inhibitory effects on receptors for some neurotransmitters. In Okayama we also visited the laboratory of Professor K. Iwata, who is both Dean of the School of Science of Okayama University and Professor of Animal Physiology in the Department of Biology. Professor Iwata is interested in the neurocontrol of pigment cells in fish. He has shown that there are three different kinds of pigment-containing cells and that the nervous system controls whether the pigment granules in these cells are dispersed or clumped. He has evidence that one neurotransmitter (norepinephrine) controls all three cell types, but the receptors on one cell type are pharmacologically distinct from those on the other, and furthermore norepinephrine causes just the opposite effect on the two types of cells.

This department has a very active graduate program and a remarkable variety of studies on invertebrate and fish nervous systems. Of particular interest to me are the works of Dr. T. Yamaguchi who studies the visual system of the crayfish by recording electrical activity from single neurons in the optic nerve and brain. This group uses both extracellular recordings of neuronal action potentials with metal microelectrodes as well as intracellular recordings with glass microelectrodes filled with dye or cobalt solution, allowing them to mark the specific neurons they have recorded for histologic identification. This is of considerable value in the effort to correlate cellular anatomy to function. This approach was also being used in studies on the visual brain (optic tectum) of the fish.

My visit to Okayama ended with the 26th meeting of The Research Group of Electrophysiology in Okayama, at which I presented my own research on neurotransmitter receptors on the nerve cells of the marine mollusc, *Aplysia*. Dr. K. Watanabe of Kobe School of Pharmacy presented work done with Dr. Takeuchi on the effects of replacement of chloride by various other anions on the electrical response to neurotransmitters in the African land snail. Dr. M. Matsumura of Kawasaki Medical School described experiments on contraction of crayfish muscle fibers. One of my most pleasant times in Japan followed this meeting, for at the party following, several of the faculty and students played the shakuhachi, a bamboo flute without a reed, and the koto, a 13-stringed, large, wooden, ancient instrument. These instruments appear to me to be extremely difficult to play

but they produce a hauntingly beautiful sound. We ended the evening by singing Japanese songs, and the whole experience is one that is unforgettable.

From Okayama I traveled to Fukuoka and visited the laboratory of Professor Yutaka Oomura at the Department of Physiology, Kyushu University. The laboratory staff uses a variety of preparations to study neurotransmitter actions of neuronal function. They use the isolated nervous system of the nudibranch mollusc, *Onchidium*, to determine the chemical structure of various specific neurotransmitter receptors. While a detailed understanding of receptor structure is not presently possible, this laboratory has made considerable progress by determining sensitivity of different receptors to enzymes that are known to act on different specific chemical groups. The laboratory also has a major effort in studying neurons in the lateral hypothalamus in monkeys and rats, but this work will be described in a different article on primate research.

While in Fukuoka, I visited Drs. N. Hori and K. Ikeda at the Department of Pharmacology in the Dental School of Kyushu University. These scientists were the first Japanese I met who were using brain slices to study the nervous system. Brain slices have become a very popular preparation recently, and they have enormous potential for allowing a much more rigorous analysis of mammalian central nervous tissue than previously possible. The slices are prepared by very quick removal of the brain from the animal, then quickly cutting a slice of brain not more than 0.5-mm thick. This slice will function relatively well for several hours if kept well-oxygenated, maintained in a control chamber, and perfused. This allows one to study an isolated mammalian tissue as one does invertebrate tissue: that is, in a preparation with control over composition of the bathing solution. In this laboratory they were primarily interested in mechanisms underlying experimental epilepsy, and they studied slices of hippocampus, hypothalamus, and pyriform cortex.

My next stop was Kurume University School of Medicine, where I visited Professors K. Koketsu and S. Nishi, who head two departments of physiology. While I was familiar with some aspects of their interests (especially concerning the study of potentials generated by electrogenic sodium pumps), I was very impressed by the great variety of projects and the number of quality of their associates and students.

Dr. K. Kuba is one of Professor Koketsu's associates, and he will soon become Professor of Physiology at the new Saga University School of Medicine. He described studies on ganglion cells from bullfrog that can be well-maintained in isolation from the animal. He studies several properties of the ionic currents involved in the electrical responses of these neurons. Of particular interest were some large hyperpolarizing responses that occur spontaneously at intervals in 3 mM caffeine. Since caffeine is known to cause release of calcium from intracellular stores in muscle, these observations suggested a similar mechanism might exist in nerve. He has both pharmacologic and anatomic evidence to substantiate this.

Drs. Kuba and Koketsu have active projects in several other areas, including the role of gamma aminobutyric acid (GABA) in the mediation of presynaptic inhibition (the process whereby the nervous system acts to depress incoming afferent information before it activates the second cell in the spinal cord). They have evidence that epinephrine may also be involved in this regulatory process. Also there are several studies on potential generated by active sodium transport using heart muscle and some peripheral nerves. By using a technique known as the "sucrose gap," it is possible to record essentially averaged intracellular potentials while having control of the external medium. The results of most interest in this study are that the electrogenic pump may generate a considerable potential, and the neurotransmitter acetylcholine may stimulate this pump. Epinephrine, another important neurotransmitter in the heart, acts to shift the threshold for turning on the pump but does not affect maximal rate. This is a most original and interesting observation.

Professor Nishi and Dr. Higashi study a number of problems in several preparations. One preparation is the isolated cat dorsal root ganglion. This preparation can be maintained in isolation from the animal for many hours, and they have studied the effects of barbiturates on the action potentials, membrane potential, and response to GABA in these neurons. At low concentrations (10^{-8} M) barbiturates increase the response to GABA.

This appears to be a result of some increase in the size of the channel for chloride, which is activated by GABA. However, at higher concentrations barbiturates appear to block sodium, chloride, and potassium channels. Dr. Higashi also has studied the effects of these cells of several drugs that are classed as neuroleptics on the basis of their use in treatment of mental disorders. While haloperidol and pimazide have been found to affect the response to GABA, this appears to be primarily a result of alteration in membrane resistance.

Other projects utilize the sympathetic ganglia of frogs and mammals and are concerned with identification of neurotransmitter substances and functions. In a major study on the transmitter involved as a mediator of presynaptic inhibition, they found no evidence for involvement of dopamine as was expected, but rather found evidence that acetylcholine is the responsible substance. In another study they have preliminary evidence that substance P, a peptide of 11 amino acids, may be the transmitter mediating the late, slow, excitatory postsynaptic potential in sympathetic ganglia.

My last stop was Tokyo, where I visited three different institutions. The first was the laboratories of Drs. Shin-ichi Terashima and Richard Goris at the Department of Physiology at the medical school of Tokyo Medical and Dental University. These researchers have contributed more than any other laboratory in the world to our understanding of a unique sensory system found in some snakes: one that responds to infrared and conducted heat. Unfortunately all snakes that have this sensory system (located in a pit between the nose and eye) are also poisonous, and therefore relatively few scientists are brave enough to work with them. Snakes with pits include rattlesnakes, copperheads, and water moccasins. The pit is without question the most sensitive organ for heat detection in the animal kingdom. The pit itself is a very thin membrane packed with nerve terminals under a thin layer of skin (keratin). The membrane is set beneath the skin surface and therefore functions as a primitive camera to detect heat from a target: for example, the body of a mouse. Drs. Terashima and Goris have studied the receptive field properties of heat-sensitive neurons at several levels of the nervous system. The peripheral afferents have receptive fields that are quite discrete and relatively small. At high levels of the nervous system, the fields are larger. Units are much more sensitive to sudden changes in temperature than to maintained temperature. This sensory system, although unique to snake, offers the opportunity to study organization of a system similar in many respects to vision but of a different modality and organization.

Next I visited the Department of Neurobiology at the Tokyo Metropolitan Institute for Neuroscience. This is a relatively new institute (about six years old), located in the distant suburbs to the west of Tokyo. My first visit was with Dr. H. Koike, who studies the giant neurons of the marine mollusc *Aplysia*, which he collects from the waters around Japan. Dr. Koike studies the movement of substances within neurons, and he is particularly interested in movement of neurotransmitters. He has previously described the active axoplasmic transport of such substances, which is an energy-requiring mechanism whereby the neuron can get necessary chemicals from the cell body to the axonal terminal. He now has evidence that probably all of acetylcholine that is transported is packaged in some way, possibly in synaptic vesicles. The movement of all free acetylcholine can be explained by free diffusion in cytoplasm. In the presence of colchicine, which blocks axoplasmic transport, all movement obeys the laws of diffusion. Dr. Koike has used this method to devise an equation to fit his experimental results. It is of interest that diffusion in the axoplasm is only slightly less than in free solution.

Dr. N. Kawai also studies an invertebrate preparation, the neuromuscular junction of the lobster. This junction is known to utilize glutamic acid as an excitatory neurotransmitter. Dr. Kawai studies the effects of various components of hornet venom on pre- and post-synaptic function. Hornet venom has at least three active components. One of these appears to be serotonin, which enhances both excitatory and inhibitory synaptic potentials. An unidentified component blocks excitatory synaptic potentials without influencing the inhibitory. Another component acts to increase membrane conductance to chloride and to thus act rather like GABA. This may be the important component to the hornet, which must paralyze its insect prey. Dr. Kawai also studies the mechanisms of presynaptic inhibition at this synapse. Unlike many other preparations, presynaptic inhibition at lobster neuromuscular junction is accompanied by a terminal hyperpolarization. However, the terminal hyperpolarization is chloride-dependent and is probably elicited by GABA as in other preparations.

My last visit was to Dr. Kunitoro Takahashi in the Department of Neurophysiology at the Institute of Brain Research of the University of Tokyo. Dr. Takahashi studies neuroembryology using a preparation that initially seems unlikely. He studies the electrical properties of the eggs of tunicates before and after fertilization. These eggs are electrically excitable like most nerve and muscle cells, but the cells are very large and can be mounted in a chamber so that the internal medium can be controlled by perfusion and the membrane voltage-clamped. He has determined how intracellular calcium ion controls the calcium transmembrane current and the currents to other ions. His work is of the highest caliber and is probably directly relevant to every nerve and muscle cell.

The laboratories that I visited are by no means all those in Japan studying the nervous system of invertebrates and vertebrates. The ones I visited were chosen because they worked in areas of interest close to my own and because I judged the laboratories to be of high quality. It has been a very stimulating experience to visit these places. Japanese hospitality and friendliness is something that has to be experienced to be believed, and I had a most enjoyable time. I certainly made friendships that will be lasting. Furthermore, the general quality of scientific work, the sophistication of laboratory equipment, and the creativity of experimental approach and design were considerably greater than I had expected. Research in membrane biophysics and general neurobiology is alive and well in Japan, and it is growing rapidly in both quantity and quality.

RESEARCH ON THE PRIMATE NERVOUS SYSTEM IN JAPAN

David O. Carpenter

In an effort to understand human behavior, intellect, and general functions of the brain, it is necessary to study lower animals in many kinds of research. The animals that most closely approach the mental capacities of man and have brains structurally most similar to man's are the primates. After the United States, there is probably more research on monkeys in Japan than any other country. This is due to both the high level of development of scientific research in Japan and to the presence of a wild native monkey population (at least 50,000) on the southern Japanese islands. Many studies are done on rhesus monkeys from India for the sake of conformity to the species most widely used elsewhere, but other Japanese studies utilize the Japanese macaque.

While visiting Japan in August and September 1978 for scientific meetings, I had the opportunity to visit five laboratories that are very active in the study of primate behavior and movement.

My first visit was to the Primate Research Institute of Kyoto University, located at Inuyama. My host was Professor Shiro Kondo, who was Director of the Institute from the time of its establishment in 1967 until recently and who has been interested in understanding human movement for many years. This Institute is the only national primate research center in Japan and has an extensive research program with active collaboration with visiting scientists, both from Japan and abroad. Housed in an impressive five-storied building on a hill, the Institute has nine research departments and employs a staff of 81 persons, 40 of whom are professionals. The Institute's stated goal is to illuminate the origin and evolution of man. To achieve that goal, basic and interdisciplinary research is carried out on the morphological, genetic, physiological, behavioral, and socioecological aspects of primates.

My visit was principally with the Departments of Psychology and Neurophysiology. The former department is interested particularly in basic processes of perception and learning, and maintenance, as well as the development of these processes. There are several laboratories studying the development and limits of visual discrimination of form and color, visual thresholds, and reaction times. The most ambitious project of this type utilized chimpanzees. It aims at determining the limits of "language" ability in these animals by measuring their ability to match a presented color or picture to one of up to 30 or more choices. In addition there is an interesting study in which DC potentials are recorded from motor cortex in animals trained to make a small movement, such as maintaining a constant pressure on a key with one finger for a variable period of time. It has been shown by Dr. Fetz in Seattle that one can condition an animal to one component of the electrophysiological response measurements in this way. Using finger pressures, the Kyoto researchers have found some higher frequency potentials riding on the slower DC shift, and they are now in the process of training the animals to eliminate this fast response. They will then compare the speed, rise time, etc., of the finger pressuring with and without the fast components of the DC shift.

Much of the work in the Department of Neurophysiology and in three of the other laboratories I visited in Sapporo and Tokyo is influenced by the techniques and experimental approach developed by E. V. Evarts of the Laboratory of Neurophysiology, National Institute of Mental Health, Bethesda, Maryland. Dr. Evarts visited the Kyoto Primate Research Institute for several months about six years ago, and there have been numerous exchanges of personnel since. Evarts' primary contribution was the development of a technique whereby a monkey earns its fluid by performing a task, such as making a single defined movement. Since the fluid reward for each correct movement is small, the animal will make the movement many times a day when presented the

opportunity to do so. After training, the animal is implanted with a cylinder over a part of the brain of interest. The cylinder allows placement and orientation of microelectrodes and makes it possible to record the extracellular discharge of neurons from behaving, nonanesthetized monkeys. Furthermore, one can compare the discharge properties of different neurons from one animal, as well as neurons from different animals, to exactly the same movement. This technique has been applied to control eye position as well as arm and leg movements in various laboratories throughout the world.

The Department of Neurophysiology is headed by Dr. Kisow Kubota. He and his associates are particularly interested in how the precentral motor cortex controls movement of the wrist. Monkeys are trained to line up indicator lights that show wrist position relative to the position required of the animal. They attempt to relate force of contraction with discharge properties of cerebral neurons and determine the influence on the neuronal discharge of anticipation and sudden last-second changes in the goal. Other experiments are geared at understanding properties of neurons in prefrontal and infratemporal cortex that are related to vision. In these experiments the monkey is trained to focus on a spot of light while holding down a lever. At an unspecified time the light grows slightly brighter. If the monkey releases the lever within a very short time after the light brightens, he is rewarded. His ability to be rewarded requires fixation and close attention to the spot, and while he is engaged, it is possible to apply other spots of light to the screen (to which he pays no attention if he is to be rewarded) and to map the visual receptive fields of central neurons responding to the second spots. While the areas studied are not in the part of cortex usually regarded as processing visual information, there are many neurons that slow responses to visual stimuli at specific locations in the visual field, and these workers are studying the properties of these neurons.

In yet another project, scientists at Inuyama have achieved a technical feat unmatched by any other laboratory in that they are able to record intracellularly from neurons in monkey cortex in the nonanesthetized, behaving animal. While Dr. C. D. Woody at University of California, Los Angeles, has used this technique in cats, it has not been applied previously to primates. The Inuyama laboratory is in the process of developing association with Woody's laboratory, which holds great promise for utilization of this procedure.

The second laboratory that I visited was that of Professor Yutaka Oomura at Kyushu University in Fukuoka. Dr. Oomura is particularly interested in the neuronal mechanisms underlying thirst, hunger, and satiation. He had shown several years ago that specific neurons in hypothalamus give electrical responses to glucose and that their activity is related to food intake. There are other neurons with specific receptors for other food products such as free fatty acids. His laboratory studied awake monkeys that could earn either food or water by pressing bars. Through chronically implanted cylinders he inserted metal microelectrodes and recorded the activity of neurons during the bar pressing and subsequent food or water reward. In the intact animal there are obviously a number of things happening together: hunger or thirst, a decision to work for a reward, the movement of bar pressing, and finally consumption of the reward. Presently they are focusing on neurons related to movement and record from both motor cortex and lateral hypothalamus. Although the former area presumably controls movement while the chemosensitive cells are in the lateral hypothalamus, there are extensive interconnections between these areas. One problem of study concerns how these two areas interact and thus determine a behavioral response.

Dr. Oomura's laboratory is one of very few in the world that utilizes primates as they probably should be, given the value and cost of each animal. The majority of research effort in this laboratory is on the same problem but uses rats. The rat experiments are clearly dictated by problems apparent from the monkey studies, but the details of the interconnections between these various brain areas are being carefully studied in acute rat experiments. The technical abilities of the people in this laboratory are quite impressive. The workers routinely record intracellularly from rat neurons, making possible a much more clear analysis of synaptic interactions. In addition, they routinely assemble electrode combinations that include a recording electrode glued to a seven-barrelled assembly of ionophoretic electrodes. The recording electrode tip protrudes slightly ahead of the ionophoretic electrode, of which each of the seven barrels contains a different putative neurotransmitter or

antagonist. Thus a cell can be recorded either intra- or extracellularly, and small amounts of each of the chemicals can be applied to determine how they affect the cell and interact with normal synaptic inputs. The techniques were most impressive, and the studies have been very productive. In addition to these acute rat experiments, Dr. Oomura is collaborating with Dr. N. Hori at the Department of Pharmacology, Kyushu University Dental School, to analyze responses of hypothalamic neurons to various substances in rat brain slices.

Next I flew to Sapporo to visit Dr. Jun Tanji (an old friend from the two years he spent in Bethesda at the National Institutes of Health) and Professor M. Kato in the Department of Physiology at Hokkaido University School of Medicine. Here I had an opportunity to lecture to medical students (neurophysiology) and was very impressed by their ability to communicate in English and their knowledge of the nervous system. The staff at Sapporo, although obviously more isolated from other neurobiologists, have an active and productive research program in mammalian neurophysiology and pharmacology. Dr. Tanji uses awake monkeys similar to those used at Inuyama, since he also trained with Evarts. His primary interest is cerebral control of movement, and he trains his monkeys to make either a finger or shoulder movement and searches for neurons in several areas whose discharges are related. He has been studying primarily an area of the brain that is separate from primary motor cortex but related to movement. Neurons in this area often discharge before those in motor cortex. Although it was questioned whether or not there was full representation of all body movements in this area, Dr. Tanji's results indicate that all areas are represented, and his results provide important insights into the function of this poorly understood area.

Professor Kato performs research on cats and that ultimate primate, man. Professor Kato's interests are on the nature of sensation and movement including properties of afferent fibers, their projection, processing of their information in the spinal cord, and the identity of neurotransmitters involved in their pathways. Many of these problems can only be approached in lower animals, but he has made considerable effort and progress in the study of such receptors in man. This is done by inserting a very small tungsten electrode into a human peripheral nerve, then recording the discharge of motor or afferent fibers while stimulating them by their normal physiological mode of excitation. It was impressive to see the laboratory of someone who uses humans when possible but also studies the same problems in animals when more rigorous methods are required.

My last stop was Tokyo, where I visited two institutions, both of which had several laboratories using primates. The first visit was with Dr. Hiroaki Niki, Department of Psychology, University of Tokyo. Dr. Niki, who has also trained in Evarts' laboratory, uses the techniques of recording from neurons in awake monkeys trained to a variety of tasks to study more behavioral aspects in the prefrontal cortex. This area has no specific motor function, but is more involved in emotional aspects. One of his more interesting observations is the finding of neurons that only discharge when the animal makes a mistake. He calls these "error neurons" and has also found such cells in hippocampus, which is another area thought to be involved in learning and memory.

The second visit was to the Department of Neurophysiology at the Institute of Brain Research, a part of the medical school at University of Tokyo. This is an impressive department headed by Professor H. Shimazu, who is particularly interested in understanding several aspects of the vestibular system. In his studies of acute cats, he records from neurons controlling eye movements (abducens nucleus) when stimulating the vestibular system by circular movement and inducing nystagmus. He is concerned primarily with elucidating the neural pathways and synaptic mechanisms that give rise to the slow excitation and fast inhibition of the neurons. In elegant and extraordinarily difficult experiments he has recorded intracellularly from one neuron while recording and stimulating others in nearby areas that are sending input to the first. He finds that the whole pattern of electrical activity in the abducens neurons during nystagmus can be explained by pathways from the vestibular nerve through intermediate relay cells, and he has recorded from all of the neurons in these pathways. It is interesting that he can explain all the discharge patterns by the turning on and off of conductance increase mechanisms which are either excitatory or inhibitory and chloride-dependent.

Dr. Y. Shinoda is also in that department and is doing equally difficult and elegant studies on the pyramidal tract system in cats and monkeys. This is the pathway from the brain that excites muscular

movements. Dr. Shinoda is concerned with the question of whether one pyramidal tract neuron makes excitatory contacts with only one muscle or a limited number of agonist muscles at one joint or whether it connects with many different muscle groups. He is using a variety of electrophysiologic and anatomic methods, and he has shown that each pyramidal tract fiber gives off several branches in the spinal cord, presumably to innervate motor neurons controlling very different muscle groups. This is a rather surprising but very clear observation. Particularly beautiful are studies in which he injects horseradish peroxidase into pyramidal axons and can use this substance to visualize the branching pattern. Although this requires enormous work, the results clearly show that a single axon is much more distributed than expected.

My final visit was to the relatively new Tokyo Metropolitan Institute for Neurosciences, where I visited in the Departments of Neurobiology and Neurophysiology. In my judgment this is one of the most exciting and stimulating research environments in Japan. The institute has 14 departments, each with a permanent staff of four to eight persons but does not have the professional system characteristic of Japanese universities. This has enormous advantages for most of the people I met. In Japanese universities there is only one professor per department and there is considerable personal power associated with the title. Thus the title may discourage easy access and open discussion. At the Metropolitan Institute, administrative duties are rotated among the permanent staff, and all members have an equal status. This makes possible an interaction that is easy and open between members and creates an atmosphere that appeared to me to be exciting and very conducive to creative work. My host was Dr. Noriichi Mano, an old friend who was the first Japanese scientist to come to Evarts' laboratory at Bethesda. Mano utilized the awake monkey conditioned to make wrist movements in different directions and at different velocities to study how activity in neurons in cerebellum are related to movement. It has been known for a long time that lesions in cerebellum cause a major disturbance of movements, but the details of what and how have not been known. Mano's study shows that the activity of cerebellar Purkinje cells, the neurons constituting the output from cerebellum, is associated with velocity of movement and not direction of movement or steady-state position. This is an important and original observation.

Dr. R. Tanaka is primarily interested in spinal reflexes, and he studies this problem in cats, monkeys, and man. He is particularly concerned with testing in human volunteers whether several reflex pathways that have been described in animals really exist in man. It is possible to elicit a number of different reflexes in man by stimulating peripheral nerves with surface electrodes, and such techniques are without hazard. Dr. Tanaka has clearly demonstrated reciprocal inhibition from Ia afferent fibers. These afferents are from muscle and make monosynaptic excitatory connections onto the motor neurons from that muscle. Reciprocal inhibition is an inhibition of the antagonistic motor neurons mediated by the same afferent fibers. Dr. Tanaka is studying several aspects of spinal cord circuitry in acute animals and is also studying humans with various peripheral nerve and muscle diseases to determine if there are disturbances in these reflexes.

Dr. T. Oshima and his associates are concerned with the mechanisms whereby lower brain stem structures that are responsible for alertness and attention mediate these effects onto pyramidal and nonpyramidal tract neurons in motor cortex. His experiments usually utilize acute cats with stimulating electrodes in the reticular formation of the brain stem. He finds a variety of different responses when recording intracellularly in different neurons, but in these studies, similarly to those of Professor Shimazu, the responses all appear to be due to conductance increase excitation or inhibition or to disfacilitation or disinhibition. Thus even in an area where conductance decrease responses are common to applied neurotransmitters, these studies have not shown this kind of response to be involved in reticular activation. Also of interest is the observation that the latency of effect is always shortest for nonpyramidal neurons at the surface of cortex. It is therefore possible that all subsequent effects on neurons in this part of cortex are mediated from a single reticular input onto primary cells in the superficial layer that sequentially connect onto other neurons.

Dr. H. Sakata studies the properties of neurons in cortical area 7 in awake monkeys. This part of the brain receives a great variety of input from sensory systems, including the eye, but its function is a matter of debate. Some investigators think this area is involved in complex perception of space, while others feel it is primarily

involved in sensory integration and has many neurons with clear visual receptive fields. Dr. Sakata finds many neurons with a clear relation to eye movements and eye position. Although he finds other neurons with clear visual receptive fields, he thinks that this part of cortex has a complex function in sensory-motor integration. He frequently uses visual illusions to study these problems.

Although I have not visited all of the Japanese laboratories that study primates, I have seen the great majority that use neurophysiological techniques in primates. My overall impression is a very favorable one. The quality and imagination of many of these studies are considerably greater than in my previous appreciation from the perspective of the United States. This probably reflects the rapidly increasing sophistication of Japanese biomedical science. Many of the investigators I visited are young, just beginning their productive life. Many have already made significant contributions, and I expect to see an increasing productivity in this important area of neurophysiology from this country.

INTERNATIONAL SEMINAR ON STRUCTURE AND FUNCTION OF RECEPTOR AND ION CHANNELS IN BIOLOGICAL MEMBRANES

David O. Carpenter

The conference was held in Okazaki, Japan, on August 27 to 29, 1978 to inaugurate the international program of the National Institute for Physiological Sciences.

This Institute and the National Institute for Basic Biology comprise the National Center for Biological Sciences which was established in May 1977 for the purpose of inter-university research. The Center is modeled in some ways after the National Institutes of Health in the United States. It differs in the fact that roughly half of its staff will be made up of visiting professors from universities in professional or associate professional positions.

A research facility of more than 10,000 square meters is being constructed to house both institutes. It is expected to be completed in two years. At that time the National Institute for Physiological Sciences will consist of four departments: Molecular Physiology, Cell Physiology, Biological Information-Processing Systems, and Biological Control Systems. Each will contain three or four major laboratories with a total teaching staff of 50 persons and a technical staff of 54.

Dr. Koji Uchizono, Director of the Institute, described its goals as follows:

"Physiology, similarly to anatomy, is a branch of science with a long history. Its goal is to explain body functions and is one of the most important basic natural sciences. It not only occupies an important place in the field of biological science but also is very intimately related to clinical and public health medical science.

The history of physiology is filled with many examples of successful application and incorporation of knowledge and principles derived from physics and chemistry. History also proves that physiology achieved considerable success in investigating and explaining the functions of organisms by analytical methods. However, an animal—especially a higher organism such as a human being—is so complicated in its physiological make-up that it is becoming almost impossible to study its integrated functions by the conventional analytical methods of natural science. The problems in physiology to be addressed in the future can be successfully solved only by careful analysis of the various functions of an organism as a whole. That is, the solution of physiological problems may lie in the combined effort of research on the basic molecular and cellular organization of an organism and mechanisms of its control systems such as the central nervous system and endocrine or hormonal system. It is also necessary to systematically organize this research into a well-coordinated, meaningful whole.

There are many well-established physiological institutes with exemplary records of performance in Europe and in the United States of America. In the past, Japanese physiology gained a great deal from these established research institutions and now has advanced itself to their level. However, the present standing of Japanese physiology is still far from the worldwide leading position that we believe is possible and hope to attain. The plan for establishing the National Institute for Physiological Sciences was initiated over three decades ago. The official inauguration of this institute

on May 2, 1977 was an epoch-making event for Japanese physiology. We are now a great step closer to realizing our dream of vast advancement in our life sciences.

In this Institute we will promote active and creative research by excellent investigators from all areas of life science in Japan. In addition we will pursue joint research by exchange of scientists from prominent laboratories throughout the world. At the same time, we propose to establish a creative and instructive environment in which to train promising young physiologists who will be able to gain a broad view in science and acquire a high level of basic technical skills. Through these efforts, we shall look forward to outstanding accomplishment as a research institute. We also hope that this institute will become a valuable source to benefit all of the leading higher institutions in this country."

The local organizer of the symposium was Professor Yutaka Oomura of Kyushu University, Fukuoka, assisted by Professor Charles Edwards at the State University of New York, Albany. There were 25 participants from Japan, West Germany, Czechoslovakia, the Soviet Union and the United States, as well as attendees from many Japanese universities and research institutes. The subject was deemed to be an important one in which considerable advances had occurred within recent years. However, these advances occurred by quite disparate approaches, and the aim of the organizers was to bring together biochemists, electrophysiologists, and biophysicists in the hope of profitable interaction among them.

BACKGROUND INFORMATION

The membranes of all living cells are composed primarily of lipid and are thus relatively impermeable to inorganic ions. However, in no tissue is the impermeability total, and the degree of permeability is not the same to all ions. Thus most neurons have high intracellular concentrations to K^+ relative to the outside medium, but very much lower concentrations of Na^+, Ca^{++}, and Cl^-. These asymmetric ionic distributions underly the special functions of nerve and muscle cells, for these cells have the ability to selectively alter their permeability to one or more ions. Since the ions are not passively distributed, there is a potential difference across the membrane. Therefore, when the permeability to a single ion is changed, this is reflected in changes in the potential. The electrical events of interest include the action potentials (relatively large all-or-none potentials which are the final output of excitable cells) as well as smaller changes in potential initiated by receptors for various chemicals. Receptor-activated permeability changes (resulting in potential changes) are the mechanism whereby one neuron communicates with another or with a muscle or other target cell. When the first neuron discharges it causes a release of a chemical which diffuses to the second and may activate specific receptor proteins. Permeability to ions across lipid membranes appears to result from several very specific proteins that span the membrane but can exist in either an open or closed (to ions) conformation. These proteins are often referred to as "channels" or "*ionophores*."

SESSION I: Na^+, K^+, AND Ca^{++} CONDUCTANCE IN THE EXCITABLE MEMBRANE

The first papers were presented by Dr. K. Takahashi of the Brain Research Institute of Tokyo University and Dr. S. Hagiwara of University of California at Los Angeles, both of whom analyzed electrical properties of eggs obtained from tunicates and starfish, respectively. Although their physiological function is unknown, these eggs will generate action potentials very similar to those that occur in nerve and muscle cells of higher animals. Because the eggs are large, easily obtained, and isolatable, they are very appropriate tissues in which to analyze (1) which ions can cross their membranes, (2) the relative time course of permeability to different ions, and (3) how the various currents can be specifically blocked. Dr. Takahashi was concerned primarily with permeabilities to Na^+ and Ca^{++}, which are the ions in all electrically excitable tissues that appear to be involved in the rising phase of the action potential. He showed that the properties of the Na^+ and Ca^{++} currents were very similar to

those in squid giant axon and crayfish muscle, respectively, which are tissues well studied in this regard. He found, however, that if the intracellular concentration of Ca^{++} was raised, then the Na^{+} current dramatically increased, whereas that to Ca^{++} fell. He suggested that these currents, particularly that of Ca^{++}, may be an important part of the changes initiated in the egg at the time of fertilization. Dr. Hagiwara described careful measurements of K^{+} currents, which are the largest resting currents and are primarily involved in the falling phase of action potentials. Some of the currents vary with the potential difference across the cell, and this property is called "rectification." Dr. Hagiwara carefully investigated the effects of varying other ions, both inside and outside the egg, on the rectifying K^{+} currents.

Dr. Manfred Klee from the Max Planck Institute for Brain Research in Frankfort on the Main described experiments on Ca^{++} and K^{+} channels in the neurons of the marine mollusc *Aplysia*. He finds two distinct types of neurons with respect to the falling phase of their action potential. In some neurons the action potential is wider and the falling phase more delayed. This appears to be due to a slow Ca^{++} permeability which induces a secondary K^{+} permeability. However, the Ca^{++}-induced K^{+} currents are sensitive to different inhibitors from other K^{+} currents.

Dr. J. M. Ritchie of Yale University described studies of the Na^{+} channels using the toxins tetrodotoxin (the potent poison from the Japanese puffer fish) and saxitoxin. These substances are specific blockers of the Na^{+} channel associated with action potentials, and by labeling these drugs with radioisotopes one can determine the number of Na^{+} channels in different tissues by measuring the binding of toxin to tissue membranes. In most excitable tissues the density is about 35-500/μm^2.

Dr. Akira Watanabe of Tokyo Medical and Dental University and Dr. Shunichi Yamagishi of the host institute described experiments on the classical neurophysiological preparation: the squid giant axon. This axon is sufficiently large that it can be cannulated and the interior solution experimentally controlled. Both men did this and studied the effects of variation of external and internal Ca^{++} on several ionic currents. These results demonstrated different effects of Ca^{++} on internal and external surfaces.

SESSION II: ANALYSIS OF CHANNEL KINETICS

This session was opened by Dr. Paul Mueller of the Eastern Pennsylvania Psychiatric Institute, Philadelphia. Mueller has used artificial lipid membranes to study the processes of ion permeability. By adding to these artificial membranes one of about a dozen substances that have been found to form ring-like holes through the membrane, one can obtain channels that allow ions to pass. He reported experiments on gramacidin and argued that the currents measured in gramacidin channels have many similarities to those of biological tissues.

Dr. Bertil Hille of the University of Washington, Seattle, presented results of a theoretical study of movement of ions through a channel in which there were multiple energy barriers. This model allows more than one ion to coexist in the channel but requires that they pass through in single file. The similarity of the calculations based on this model to measured parameters suggests that K^{+} channels may be multi-ion single-file pores. This model was extended by Dr. George Eisenman of University of California, Los Angeles, who discussed primarily the gramacidin channel in artificial membranes.

Three papers were presented on properties of Ca^{++} channels from different preparations. Dr. J. Zacher of Bratislava, Czechoslovakia, studied the currents in crayfish muscle fibers, in which the action potential is dependent on Ca^{++} rather than Na^{+}. He found that he could measure the Ca^{++} current but in addition found three different K^{+} currents. Dr. P. G. Kostyuk of Kiev and Drs. N. Akaike, S. Yasui, and A. M. Brown of Galveston, Texas, both presented studies on Ca^{++} currents in snail neurons using a technique developed by Kostyuk in which a single neuron is isolated and placed by suction into a small hole between two fluid compartments. Then the cell membranes not over the hole can be ruptured, allowing the intracellular medium to equilibrate with one

compartment. Membrane currents can then be measured as they flow across the patch of membrane that is sealed in the hole. Kostyuk described the variety of currents measured in snail neurons and analyzed their time and voltage dependencies. Akaike et al. determined the ability of other divalent cations to pass through Ca^{++} channels.

A most provocative report was made by Dr. Ichiji Tasaki of the National Institutes of Health, Bethesda, Maryland. Dr. Tasaki was a particularly important participant in the conference, since he has not only been very creative in his research in a number of areas but has also exerted a profound influence on Japanese science by directing the training of many of the Conference participants. In his studies, Dr. Tasaki used the perfused squid axon (a preparation which he developed) and examined the effects of a number of chemical stimulants and toxins, applied either intra- or extra-axonally. Using a spectrum analyzer he analyzed subthreshold electrical events that have not been seen previously. His most interesting observation was that he could induce small spikes by stimuli that did not cause changes in membrane potential. These small spikes were sensitive to toxins thought to be specific for both Na^+ and K^+ channels.

SESSION III: CHEMICAL STRUCTURE OF THE RECEPTOR AND CHANNELS

Dr. C. Edwards (Albany, New York) reported on a study of the size of the channel activated by acetylcholine in frog muscle, and concluded by using a variety of ionic substitutes for Na^+ that this channel must be about 6.4 Å in diameter. This is about twice the area of the Na^+ channel associated with action potentials. Dr. Y. Kobatake of Hokkaido University, Sapporo, studied both the receptors and channels associated with chemotactic responses of single cell animals and plants.

Reports from two laboratories dealt with the very interesting problem of the exposed functional groups in both receptors and channels. Dr. Yutaka Oomura of Kyushu University, Fukuoka, studied a response to γ-aminobutyric acid (GABA) in snail neurons. The response to GABA is biphasic, being a sequential Cl^- and K^+ permeability. He found that drugs that modify the ϵ-NH_3 + groups of lysine residues block the Cl^- responses, while drugs that affect the ^-OH groups of tyrosine residues block K^+ responses only. He found other drugs that depress both responses, and suggested that these drugs might be acting at the level of the receptor rather than the channel. Dr. Makoto Sato of Iwate University, Morioka, used Na^+ and Cl^- acetylcholine responses of a different marine snail to study the action of several enzymes. He also found that some enzymes rapidly blocked both kinds of response, consistent with action at a common receptor, while other drugs blocked one or the other ionic response, consistent with an action at one or the other channel.

SESSION IV: CHEMICAL STRUCTURE IN THE INTERNAL LAYER OF THE MEMBRANE

The studies reported here were exclusively concerned with the squid giant axon, which is one of the few tissues large enough to allow direct chemical as well as electrical analyses of the inside of the membrane. Papers were presented by Drs. Toshifumi Takenaka and Tohru Yoshioka, both of Yokohama City University. Using the Japanese squid, they perfused the axon with photo-oxidizing agents which alter imidazole groups. This procedure, after photo-oxidation, resulted in dramatic suppression of the late K^+ currents with minimal effects on Na^+ currents. Other studies used radio-labeled probes. Some of these could be bound to the internal membrane, but were then released on photo-oxidation. Other studies involved adding ^{125}I onto proteins in the membrane, separating the labeled proteins, and then determining molecular weights and whether or not the protein extended through the membrane. Tentative identification of a tetrodotoxin-binding protein was made.

SESSION V: IONIC MECHANISMS IN THE RECEPTOR MEMBRANE

The first talk, by this reporter, presented evidence from *Aplysia* neurons for the existence of specific receptors for at least nine different neurotransmitter substances. Further evidence suggests that for each

neurotransmitter at least three different ionic responses can be found, due to Na^+, Cl^-, and K^+ permeabilities. The responses that are to the same ion but initiated by different neurotransmitters have similar temporal, temperature, and pharmacological characteristics. These results are consistent with the hypothesis that the neurotransmitter receptors and ionophores (channels) for specific ion permeabilities are interchangeable entities. As yet this is only a hypothesis, but there are many important implications of this idea for the study of brains of higher animals.

Dr. Akira Takeuchi of Juntendo University, Tokyo, presented a careful analysis of the Cl^--dependent currents elicited by GABA in crayfish muscle. His primary interest was in the voltage dependence of this response, which is not the same as found at frog neuromuscular junction. He suggested the possibility that this might be secondary to the difference in neurotransmitter substances. If so, this implies an influence of the receptor on the ionophore in some way not presently understood. Dr. Takaski Maeno of Shimane University, Izumo, reported on a drug that appears to shift the relative Na^+/K^+ permeabilities at frog neuromuscular junction. This drug increases Na^+ and decreases K^+ permeabilities, but how it does so is not known.

Finally, Dr. Rudolfo Llinas of New York University presented a model of synaptic transmission based on his study at the giant synapse of the squid stellate ganglion. By voltage clamping both pre- and postsynaptic axons and by blocking Na^+ and K^+ action potential currents with drugs, he was able to study the process of Ca^{++} entry into the presynaptic terminal and the consequent release of neurotransmitter and currents produced in the postsynaptic axon.

As with all scientific meetings, this one did not have all new information, and some areas of research were not as well covered as they might have been. But the meeting was both stimulating and provocative, and the discussions were lively after almost every paper. Perhaps even more important than the scientific success was the personal interaction and friendships formed here between Japanese scientists and Western colleagues.

The hospitality of our hosts for this meeting surpassed even the traditional Japanese standards. Professor Yasuji Katsuki, President of the National Center for Biological Sciences, not only entertained us royally at social events, but also partook in all of the scientific sessions. Professors Katsuki, Uchizono, and Yamagishi earned both the gratitude and affect of the participants. We are very grateful for the opportunity to take part in the first international meeting, and hope that their new Center and Institute grow to achieve the promise they show.

THE SIXTH INTERNATIONAL BIOPHYSICS CONGRESS* KYOTO, JAPAN

David O. Carpenter

The International Union for Pure and Applied Biophysics, together with the Science Council of Japan and the Biophysical Society of Japan, sponsored the Sixth International Biophysics Congress, held on 3 to 9 September 1978 at the Kyoto International Conference Hall. The Conference was attended by more than 2000 persons from 40 countries.

The opening ceremony was chaired by Dr. Fumio Oosawa, Secretary General of the Congress. Welcome to Kyoto was given by Dr. Koji Fushimi. President of the Science Council of Japan, and Dr. Ei Teramoto, President of the Biophysical Society of Japan. Dr. Maseo Kotami, Chairman of the Organizing Committee, extended the welcome and reviewed the history of biophysics. He noted that whereas physics and chemistry were united in the 1930's, biology and physics came together at a much later date. This general theme was embellished in the primary address of the evening given by Dr. Britton Chance, President of the International Union of Pure and Applied Biophysics. He noted that the new directions in biophysics were often difficult to predict. Although biophysics is a problem-oriented rather than technique-oriented discipline, the new directions and indeed the limitations of development have been often technique-related. Dr. Chance listed a number of areas wherein there have been recent considerable technical advances, especially radiation biophysics and the new and exciting developments in an effort to control fusion energy. However, in spite of major advances in these many technical areas, there is a need for development of even higher resolution methods in the study of cellular, enzymatic, and ionic ultrastructure.

Dr. Chance suggested that a major challenge in biophysics for the future is the development of nondestructive biophysical probes to study living tissue without damage. Such new biophysics has the potential for enormous use in medicine. Specific areas in which valuable application to contemporary medicine is both needed and possible include echo-cardiography, radiation (especially X irradiation as used in computerized X ray tomography), and nuclear magnetic resonance zengmatography to study cell water in living human systems.

The opening session was followed by one of the most beautiful and luxurious receptions that this author has ever enjoyed at an international conference of this size. The Kyoto International Center, with its pools, fish, gardens, and lovely rooms, was a beautiful setting for Japanese food and drink that was plentious, beautiful, and luscious. This was followed by Japanese dances and fireworks.

The scientific sessions were scheduled primarily from Monday through Friday. There were three symposia scheduled for each morning and each midafternoon, and poster sessions were set up for early afternoon. The symposia covered a wide range of topics in biophysics, all of which cannot be reported in detail. Those that I attended reflect my personal primary interests in nerve and muscle.

One particularly interesting symposium held the first morning followed the tone set by Dr. Chance in his opening address. It concerned new technology that allows three-dimensional studies of body structure. The first speaker, Dr. Lee D. Peachey (United States) described use of high-voltage electron microscopy in giving three-dimensional views of the transverse tubular system of skeletal muscle. He was able to selectively stain this

*Additional information of this important meeting is reported in the preceding issue of the *Scientific Bulletin*.

system, and the audience, with 3-D glasses, was able to visualize this remarkably beautiful network of small tubules that control muscle contraction by regulating the release of Ca^{++}. Following this talk, Dr. H. Takasaki of Japan described the new techniques of moiré topography. This method of illuminating contour maps of forms such as the human body is widely used now in Japan but is new to most of the rest of the world. Basically simple in principle, it has many potential applications in medicine, such as being a valuable aid in the construction of an artificial limb to be an exact replica of the removed limb. Dr. Takasaki even illustrated an averaged contour map of finalists in a beauty contest, although most of us preferred the individual variations between contestants.

Dr. P. C. Lauterbur discussed the possibility that nuclear magnetic resonance zengmatography of cellular water may be used in clinical medicine. In several countries, magnets are being constructed that are large enough to analyze a whole human. Although the potential and limitations of this technique still are fairly unknown, it is known that there are changes in the water signals in small animals with cancer. This is one area that may have application to medicine. As a general principle, there is great potential for using many of these noninvasive or only moderately invasive analytic techniques, applied with computer analysis and reconstruction of a three-dimensional signal.

On Monday afternoon there was a very interesting symposium on analysis of visual information in the nervous system, organized and chaired by Donald MacKay (United Kingdom). This symposium at first seemed surprising for a biophysics conference, since most of the presentations were concerned with electrophysiological analysis of neuronal networks in brain, and there was not very much of this kind of central nervous system electrophysiology at this conference. However, there appears to be a historical link between biophysics and sensory physiology and psychophysics that does not exist with the rest of central nervous system physiology. In any case, the symposium was superb, with presentations on visual discrimination in insects (W. Reichardt, Federal Republic of Germany), cat retinal ganglion cells (Y. Fukada, Japan), mammalian and primate visual cortex (K. Toyama, Japan; T. N. Wiesel, United States), and primate superior colliculus (R. H. Wurtz, United States). Although the complexities of the circuitries increase both as one advances up the evolutionary scale and also as one goes from the peripheral sense organ to the central nervous system, the symposium emphasized that there are a number of general principles of analysis of visual data that operate at these widely varying levels.

Another excellent symposium was on the topic of the molecular basis of excitability, and this session was chaired by Dr. S. Hagiwara of Los Angeles. Although electrical excitability is usually thought to be a property only of nerve and muscle, it is becoming increasingly apparent that many types of cells will exhibit action potentials and therefore are suitable preparations in which to study the mechanisms underlying excitation. For example, Dr. K. Takahashi of Tokyo University described studies on the egg cells of the tunicate. These egg cells will give rise to action potentials, and even after fertilization and division into a multicellular structure, each cell is excitable. Because they are large, these cells are convenient preparations in which to study the ionic channels that underly excitation. Dr. W. K. Chandler (United States) described how muscle membrane potential controls release of Ca^{++} from intracellular structures and how Ca^{++} in turn controls contraction. Dr. R. D. Keynes (United Kingdom) discussed problems concerned with "gating" of ionic currents in squid axons, and Dr. P. G. Kostyuk (Union of Soviet Socialist Republics) described the channels for Ca^{++} in snail neurons. Dr. Kostyuk has developed a beautiful technique in which a single giant snail neuron is isolated and mounted in such a way that both internal and external media can be controlled. Dr. P. Lauger (Federal Republic of Germany) described studies on the gramicidin channel in artificial membranes. The use of antibiotic substances that will form channels in artificial lipid membranes has provided a superb model system for study of properties of a single channel species under controlled conditions. Although such channels are certainly not identical to those existing in excitable tissues, they have many common features.

Dr. J. Adler (United States) organized an interesting symposium entitled "Supracellular Biophysics." This concerned sensory behaviors exhibited by bacteria (temperature senstivity, Dr. F. Oosawa, Japan; chemotoxin, Dr. J. Adler, United States; sensory transduction, Dr. D. E. Koshland, United States). For more complicated systems, Dr. S. Benzer (United States) described studies on the neurogenetics of behavior in the fruit fly, and Dr. M. Jacobson (United States) discussed an analysis of brain development using mosaic frogs.

Thursday was a big day on muscle contraction, with two excellent symposia on "Primary Processes in Muscle Contraction" chaired by D. Wilkie (United Kingdom) and "Contractile Proteins in Muscle and Their Tissues" chaired by W. Drabilkowski (Poland). The first session concerned cross bridges in insect muscle (K. C. Holmes, Federal Republic of Germany) and vertebrate muscle (M. F. Morales, United States), X ray defraction studies of contracting muscle (H. E. Huxley, United Kingdom), the structure of myosin (Y. Tonomura, Japan), and the nature of interaction between myosin and action (A. Weber, United States). The second symposium concentrated on a variety of contractile proteins in muscle and other tissues. Dr. John Gergely (United States) discussed molecular motion and conformational changes of proteins during muscle contraction, and Dr. A. G. Szent-Gyorgyi (United States) discussed myosin-linked calcium regulation. Dr. K. Weber (Federal Republic of Germany) presented a fine talk on the cytoplasmic organization of microfilaments, microtubules, and intermediate filaments. He has studied these subcellular organelles with electron microscopy and immuno-fluorescence. Finally, Dr. S. Hatano of Japan discussed contractile proteins in *Physarum plasmodium.*

The final symposium that I attended was one of the most interesting of the conference, and was titled "Animal Communication in and with the Environment," chaired by Dr. M. Lindauer (Federal Republic of Germany) and Dr. T. Hidaka (Japan). Dr. Lindauer presented the first paper on communication in honey bees and ants. He presented the remarkable story of how one honey bee relates to another the location of a bowl of sugar water. Bees that discovered the bowl by chance were marked with a spot of paint. When they returned to the hive they performed a dance, as was shown in a movie. The dance had a repeating pattern. The bee would outline a semicircle in each part of the dance, alternating between the right and left halves, so that on a full cycle it would make a full circle bisected twice in the middle. Dr. Lindauer and his associates have found that the angle of the bisection conveys to the other bees the direction toward the food. Further, since the angle of the dance varies at different times of day when the bowl is at the same site, they believe the angle is related to food position relative to the sun. When the bee bisects the circle he shakes his abdomen, and the other bees all cluster around him, touching and feeling his dance. Frequency of the abdominal dance conveys information about distance of the food from the hive.

The other papers in the session dealt with sex pheromones in insects (Y. Tamaki, Japan), electric organs in fish (H. W. Lissman, United Kingdom), the biosonar system in bats (N. Suga, United States), and the effects of different environments on sound communication (A. Michelsen, Denmark). This last paper was of particular general interest and dealt with the effects on sound propagation of different obstacles. Thus a cricket chirping in the grass may make a sound that carries for a long distance when heard by a human whose ears are located free of interfering structures, but the sound may carry for only relatively short distances to another cricket in the grass.

This conference was in the planning stage for over two years, and it operated on a budget of over 80,000,000 yen. Of this amount approximately one-third came from registration fees, one-third from private Japanese companies and foundations, and one-third from the Japanese government. Many younger foreign scientists received travel grants from friends of the International Union of Pure and Applied Biophysics. The next meeting will be held in Mexico City in 1981.

In retrospect, this meeting was thoroughly delightful and scientifically rewarding. It provided an opportunity to meet international friends of long standing and an opportunity to make new friends. It opened a window to the development of Japanese biophysics, which has grown and matured at a remarkable pace.

SIXTH INTERNATIONAL BIOPHYSICS CONGRESS*

H. W. Huang

The last thirty years have seen molecular biophysics become the driving force of all the biological sciences. Ingeneous spectroscopic analyses have been applied to elucidate the molecular details of important proteins and organelles. Sites of enzymatic action in many proteins have been identified. In the meantime thermodynamic, including chemical and electrical, variables of biological functions have been measured and correlated. Of them, perhaps the most important discovery is the allosteric regulation. A binding at a regulatory site often changes the affinity of another binding site 20 or 30 Å away in a protein. To understand such cooperative phenomena in proteins has been the motivation behind the intensive research on hemoglobin. Quantum phenomena have also been found in biological functions. In particular the rate of electron transfer in cytochrome exidase becomes temperature independent at low temperatures; it indicates that the electron transfers between molecular centers by quantum tunneling through a potential barrier. The continued effort to gain microscopic information and to understand the enzyme mechanism were the two main themes of the Sixth International Biophysics Congress, held 3-9 September 1978 in Kyoto, Japan.

The following is a selection of fundamental subjects reported in this Biophysics Congress.

HEMOGLOBIN

By far hemoglobin is the most thoroughly studied allosteric system. The atomic coordinates have now been determined to within 2Å. However the structural basis of cooperativity is still unclear. There were reports on NMR and theromdynamic studies. For example it was found through high-resolution NMR studies that introducing organic phosphate, IHP or DPG makes α hemes have a higher affinity for O_2 than β hemes, whereas in the absence of these solutes, α and β have the same affinity. The same NMR report implied that there are ligand-induced conformation changes in the unliganded subunits of a Hb molecule upon oxygenation and that there are more than two structures in going from the deoxy to the oxy state. Another experiment (K. Imai, Department of Physicochemical Physiology, Medical School, Osaka University) determined the enthalpy and entropy changes of each oxygenation step by measuring the oxygenation isotherms at six different temperatures. It appears that, after thirty years of extensive experimental investigation, we are still not able to locate the energy of cooperativity in Hb. From the EXAFS studies, one finds that the iron displacement between the R and T forms is about or less than 0.2Å. That accounts for one third to one half of the energy of cooperativity. Where the rest of the energy is distributed remains unclear.

CYTOCHROMES

Cytochromes play the essential role of electron transfer in the respitory cycle in which the energy of glucose is utilized and oxygen combines with proteins to form water. Although how the electron transfers from one molecular center to another is still unknown, a quantum phenomenon was revealed in the process. The light absorption spectroscopy can be used to monitor the electron transfer from one cytochrome to another. The rate of transfer in cytochrome oxidase was found to become temperature independent at low temperatures. That

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means the reaction does not involve an activation energy. In other words, the electron tunnels. The quantitative interpretation however is not settled yet. More experimental data such as EPR and Raman are needed.

RIBOSOME

Small angle neutron diffraction has been used to study the arrangement of proteins within the 30 S ribosomal subunit of E. Coli. This work represents a pioneering effort in applying the neutron scattering technique to study biological systems. However this method would have difficulty if the shape of the protein is extended rather than globular. And the result so far does not agree completely with that of the immuno-electron microscopy.

MEMBRANE

In recent years, the interest on membrane has shifted from the study of lipid bilayers to the study of the membrane bound proteins. The technique of immuno-fluorescence, which was the first method used to study the diffusion of proteins in fused cells, has now evolved into the fluorescence correlation spectroscopy and the fluorescence bleaching method. It is now possible to study the motion of proteins in a small area of the cell membrane. The membrane proteins diffuse with $D \sim 10^{-10} cm^2$ sec, nearly two orders of magnitude slower than the lipid analogs. As one expected, capping is a flow rather than diffusion process.

MUSCLE

The central issue was the mechanism by which the myosin cross-bridges develop the sliding force between the actin and myosin filaments. The technique of short time small angle X-ray diffraction was developed to monitor the motion of the cross-bridges during contraction. Synchrotron radiation made it possible to shorten the time resolution to about 10 msec. Data did show movement of cross-bridges perpendicular to fiber. The physical properties of the two-headed structure of myosin were studied in vitro. By the time-resolved fluorescence anisotropy decay, it was demonstrated that the cross-bridge structure rotates at the (S-1) - (S-2) junction. Another report (Y. Tonomura, Department of Biology, Faculty of Science, Osaka University) suggested that two heads are not identical and one is for contraction, another for relaxation. Using arsenazo probe and light absorption it was also learned that calcium is released but there is no change in pH and [Mg] in skeletal muscle when it is stretched. How chemical energy is converted into mechanical work remained unanswered.

PHYSICAL METHODS

The new physical methods for biological applications developed in the recent years include high resolution NMR (including the J-resolved two-dimensional method), extended X-ray absorption fine structure and absorption-edge fine structure using synchrotron radiation, X-ray diffraction (including the small-angle technique) using synchrotron radiation, high voltage electron microscopy, light absorption (G. B. Benedek and T. Tanaka, Physics Department, Massachusetts Institute of Technology, Cambridge) and fluorescence spectroscopy using a variety of new probes, and fluorescence bleaching method.

Readers interested in this Conference should consult the abstracts published by Science Council of Japan, Biophysical Society of Japan, 1978.

AQUATIC SCIENCE, KYOTO UNIVERSITY

Francis A. Richards

Although Kyoto is an inland city, it is not far from the Seto Inland Sea, Lake Biwa, and the Sea of Japan. Thus there is considerable activity in various aquatic sciences at the University. The branches I visited were the Research Institute for Food Science in Uji (a Kyoto suburb), the Department of Fisheries of the College of Agriculture, the Department of Chemistry of the Faculty of Science, and the Laboratory of Radiochemistry of the Institute of Chemistry. I did not visit Professor Hideaki Kunishi, who occupies the Chair of Physical Oceanography in the Geophysical Institute and whose work is described elsewhere in this issue ("A Glimpse of Physical Oceanography Programs in Japan" by Takashi Ichiye).

The Department of Fisheries of the College of Agriculture has four chairs, Fisheries Chemistry, Fisheries Physics (which is actually physical oceanography), Fisheries Microbiology, and Fishery Biology. The research in the department is generally more fundamental than that in the various Fishery Agency laboratories, and such problems as basic biochemistry, functional morphology and life histories of fishes, and taxonomy of microorganisms are investigated.

A common interest of many of the groups in the university is the investigation of the outburst of red tides on Lake Biwa (Biwako). Biwako is the largest lake in Japan, a recreation center, and is the water supply for a large population in the surrounding country. The *biwa*, a lute-like Japanese musical instrument, has large and small parts, as does the lake, and from this imagined similarity the lake gets its name. The small part is to the south, is surrounded by rather dense population centers, and receives both industrial and domestic pollution. Rather strangely, outbreaks of red tide (*Akashio*) have occurred recently in the large, northern, relatively unpolluted part of the lake.

"Red tides" can be variously defined. They are accumulations of any of a number of microorganisms but generally dinoflagellates. The accumulations may be toxic or otherwise harmful to aquatic life. In Biwako the organism is probably a species (or perhaps more than one species) of the genus *Uroglena*, or it may be *Uroglenopsis americana*, although it is strange that an organism with such a name should inhabit a Japanese lake! In any case, specific identification of the organisms is difficult because it depends on the morphology of the encysted form, and it is difficult to induce encystment in laboratory cultures. For sake of definition, a red tide contains 1000 or more organisms per milliliter and causes a visible discoloration of the surface water. Actually, maximum concentrations frequently are 2 or 3 meters below the surface. A red tide may appear and disappear in a day. Although the Biwako red tides appear not to be toxic, many are and kill various marine organisms. In other cases the marine organisms are not killed but toxins are accumulated, notoriously by shellfish, which then become toxic to higher organisms, including man. Damaging red tides of the dinoflagellate *Hormilla marina* occur in the Seto Inland Sea, and these may kill yellowtail, *Seriola quinqueradiata*, fish that are widely cultivated in the sea.

The exact conditions and processes responsible for the occurrence of red tides are generally unknown. In some cases excess supplies of phosphates and nitrogen compounds seem to be implicated, but this appears not to be the case in Biwako. In the Seto Inland Sea there are good correlations among red tides, high temperatures, and low salinities, the latter following heavy rainfall.

To attack the problem of the red tides in Lake Biwa, a working group has been formed, headed by Professor Hajime Kadota of the Department of Fisheries, Kyoto University. The members of the working group

are from the Department of Fisheries, Otsu Hydrobiological Station, and the Research Institute for Food Science, all of Kyoto University, the Limnological Institute of Shiga University, the Department of Science of Osaka Educational University, and the Departments of Agriculture of Kinki and Kagawa universities. Topics being investigated by various members of the working group are: 1) Distribution and mechanisms of accumulation of *Uroglena*, 2) Distribution of growth promoting substances determined by bioassay with *Uroglena*, 3) Interactions between heterotrophs and *Uroglena*, 4) Life cycle of *Uroglena*, 5) Distribution of Vitamin B_1, biotin, B_{12}, and heavy metals in Lake Biwa, 6) Primary production in Lake Biwa, 7) Distribution and grazing rates of zooplankton, especially those grazing on *Uroglena*, 8) Release of inorganic nitrogen compounds and vitamins from Lake Biwa sediments, 9) Physical properties of lake water in relation to accumulation of *Uroglena*, 10) Effects of *Uroglena* blooms on the physiology of sweetfish, trout, carp, and other fish, 11) Chemical properties of lake water and the nitrogen cycle in the lake, 12) Classification of net, nano, and ultramicroplankton (phytoplankton) and 13) Toxins in *Uroglena*. Most of the group members have other research interests but are now turning at least part of their attention to the Biwako *Akashio* problem.

Dr. Yuzaburo Ishida, who is concerned with growth promoting substance and their effects on the *Uroglena*, is also working on structural changes in bacterial communities caused by environmental pollution and eutrophication, especially in Osaka Bay and Lake Biwa. He is working on the culture and identification of *Uroglena* species and is studying their morphology with the aid of scanning electromicroscopy, using both cultured material and "wild" organisms from the lake. He is also carrying out bioassays for substances promoting the growth of *Uroglena* using lake water and soil extract. He can now culture the organisms in chemically defined media, but he must use lake water if his results are to apply to Lake Biwa.

So far no toxins have been identified in the Lake Biwa *Uroglena*, but 13 and 14 carbon fatty acids have been separated from lipids in the cells. Work elsewhere suggests that the dinoflagellate *Harnellia marina*, which occurs in the Seto Inland Sea and around Kagoshima, may produce surfactant substances, possibly fatty acids, in the gills of fish and cause damage.

The reasons for the outbursts of red tides in Biwako are unknown, but apparently high concentrations of nitrogen and phosphorus compounds can be ruled out. Dr. Akira Kawai of the Research Institute for Food Science suspects that substances released from the sediments may stimulate the multiplication of the organisms. Suspect materials include vitamins, chelated heavy metals, nitrogenous materials, etc. Dr. Kawai has been sampling the sediments of Biwako on a regular basis to determine the rates and amounts of liberation of nitrogen and phosphorus compounds from the sediments to the water. Both the total sediment and the pore waters are analyzed. He is also attempting to determine the rate of liberation of vitamins and heavy metals.

In Biwako sediments, Kawai has found that most of the amino nitrogen is present in solid, not soluble forms. He has outlined five processes involved in the production and liberation of ammonia:

1) Sedimentation of particulate organic nitrogen (PON).
2) The production of ammonia from PON in the mud.
3) The partition of ammonia between the interstitial water and mud particles.
4) The migration of ammonia in the interstitial waters. He assumes a diffusion rate of $1.3 \times 10^{-6} cm^2\ sec^{-1}$
5) Liberation of ammonia from the interstitial water into the overlying water.

It is apparent that this model would apply to other constituents, such as phosphorus, vitamins, and chelated heavy metals.

Kawai can now calculate seasonal changes in the rates of release from the distributions in the cores and the diffusion coefficient. The rates of release of ammonia and phosphate are generally high in summer and low in winter. The rate of release of phosphate from oxidizing sediments is much lower than in reduced ones, but the oxidation state makes little difference in the rate of release of ammonia.

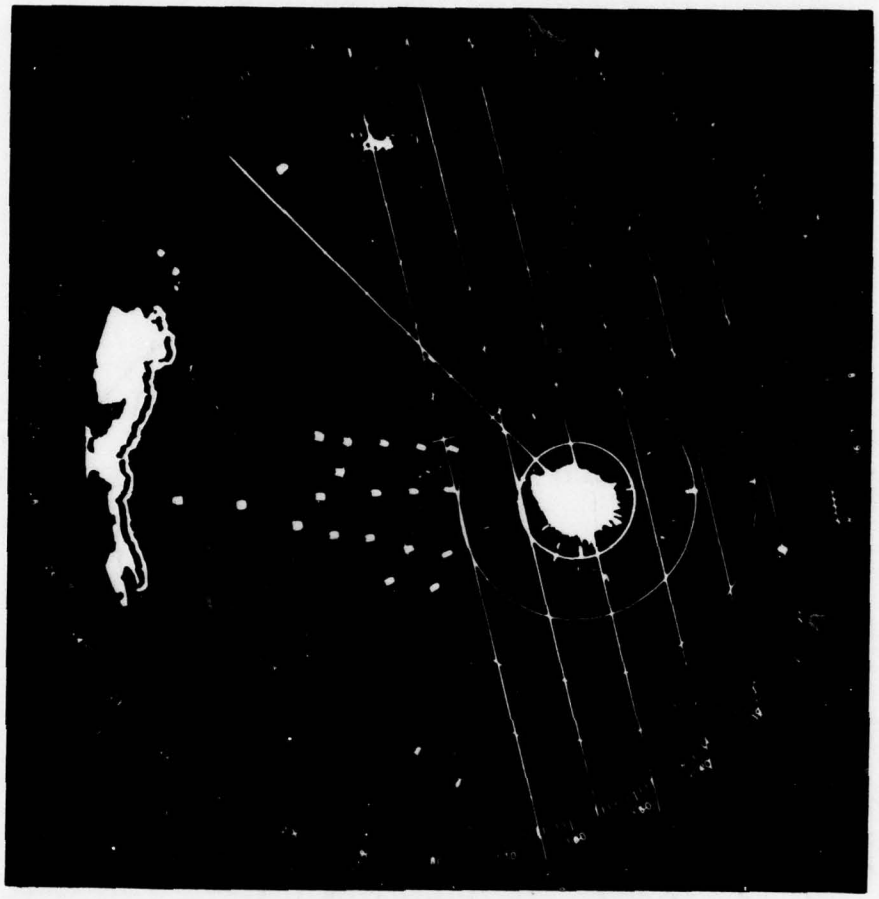

Figure 1A. Radar Screen Photograph of original positions of floats deployed in Western Wakasa Bay. Time: 1130 hours on 9 August 1978. North is at the top of the photograph. The rings are one-half mile range markers. (Photograph courtesy Professor H. Kawai and The Geophysical Institute, Kyoto University.)

Researches in the Faculty of Fisheries also include topics such as the systematics of various fishes, benthos ecology, functional morphology of fish larvae particularly *tai* (*Telapia* sp.) and some flat fishes, fat absorption in the gut of fish larvae at critical times in their development, chemoreception by fish larvae in relation to their feeding habits, taxonomy of fishes, and the life history of the gobioid fishes of the genus *Acanthogobius*. Botanical studies include work on the taxonomy of blue green algae and the life histories of red algae. Dr. Hajime Kadota, Professor of Microbiology in the Department of Fisheries, and Dr. Ishida are working on the culture of aquatic bacteria using low concentrations of nutrients–systems more like nature than the high concentrations ususally used in laboratory cultures. Nutrients labeled with radioactive carbon-14 are used to follow growth more sensitively–necessary because of the low-nutrient conditions.

The chair of Fisheries Physics in the Department of Fisheries is held by Professor Hideo Kawai, who spent some time at Woods Hole Oceanographic Institution. A physical oceanographer, Professor Kawai has recently completed experiments in which the diffusion of 16 floats released in a cluster on the sea surface was followed by radar and recorded photographically every five minutes. The experiments were carried out on Wakasa Bay on

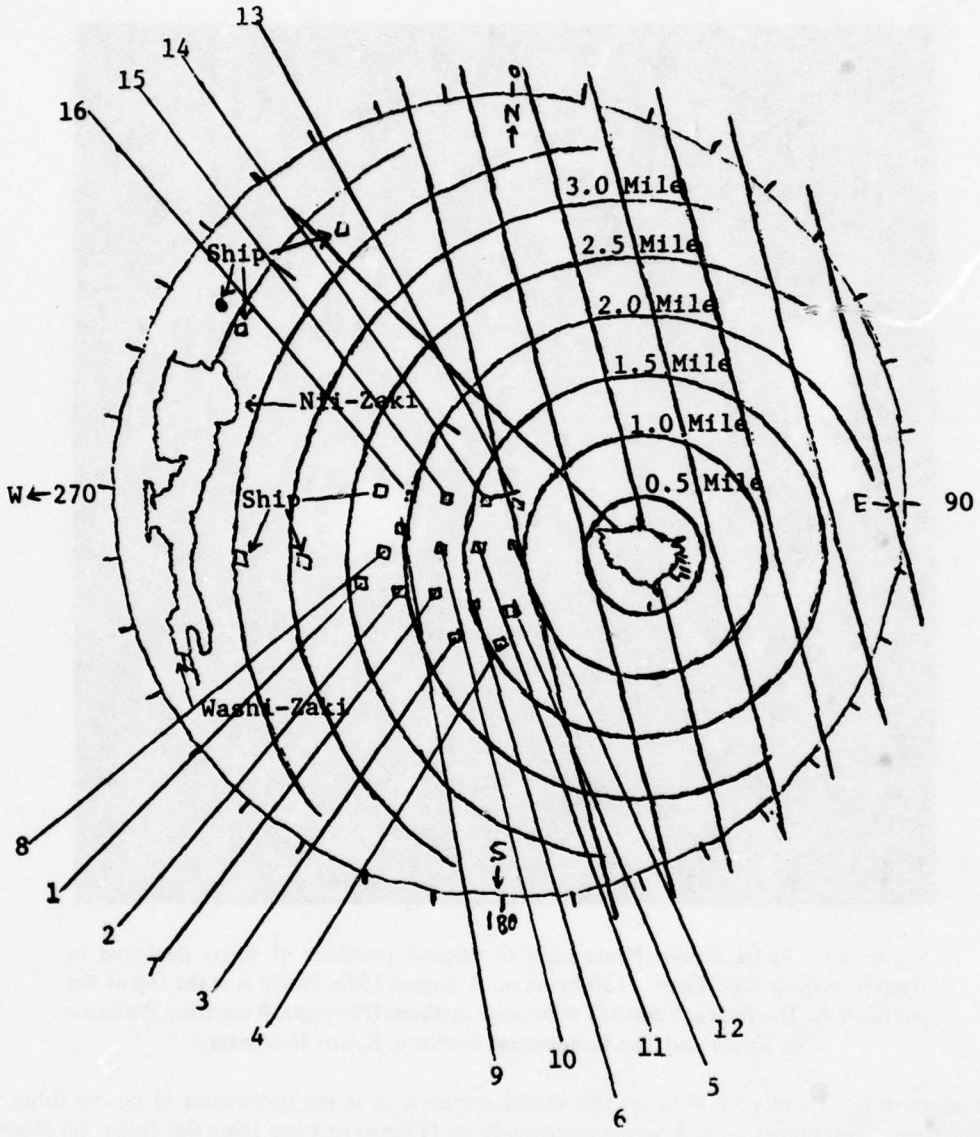

Figure 1B. Reversal of Figure 1A with explanatory information affixed.

the Japan Sea coast. Rather surprisingly after several hours the floats arranged themselves in two lines, radiating some 60° apart from the inner part of the bay (Figures 1 and 2). It seems the floats were placed in a divergence zone that neatly bifurcated the group.

Along with many Japanese (and non-Japanese) oceanographers, Kawai is interested in the Kuroshio Current and its effects on the fishing grounds. With his Woods Hole experience, he is also interested in similarities and differences between the Kuroshio and the Gulf Stream. Like the Gulf Stream, the Kuroshio forms large loops during its meanderings; these loops can pinch off and form a ring of Kuroshio water surrounding colder water if

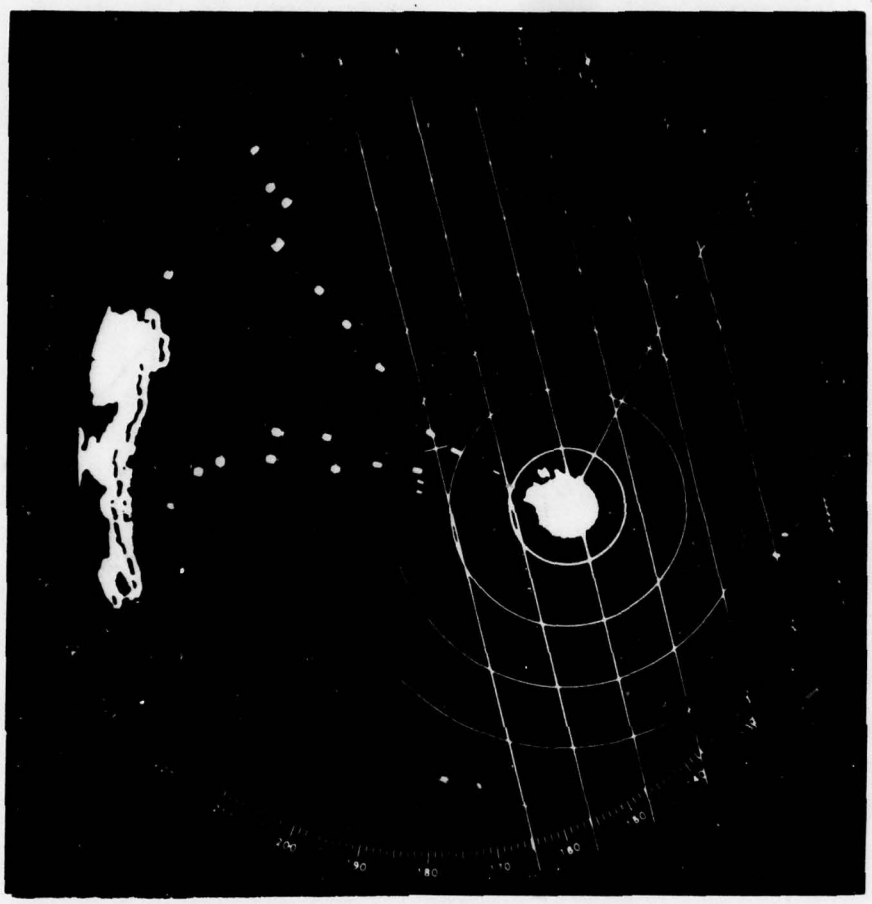

Figure 2A. Radar Screen Photograph showing displaced positions, after three hours, of floats deployed in Western Wakasa Bay. Time: 1430 hours on 9 August 1978. North is at top of the photograph. The rings are one-half mile range markers. The lines of floats radiating in the 320°-330° sector and in the 260°-280° sector were in lines of slicks. (Photography courtesy Professor H. Kawai and The Geophysical Institute, Kyoto University.)

the circulation of the ring is cyclonic, warmer water if the opposite is true. Generally, the cold rings form east of Japan, but in a rare case in 1977, one formed at about 135°E, the longitude of Osaka Bay. By correlating physical oceanographic data observed and published by the Hydrographic Office of the Maritime Safety Agency and fisheries catch statistics from the Service Center for Fisheries Information in Tokyo, Kawai has found a relationship between Kuroshio rings and the fishing grounds for albacore and skipjack tuna. The albacore avoid the cold centered rings, but skipjack apparently seek regimes of variable oceanographic properties. Although the main skipjack fishing grounds are generally further east, in 1977 they were taken in the area of the unusual cold ring at around 135°E.

Kawai is also studying the effects of thermal discharges from many nuclear power plants around Wakasa Bay, Kyoto Prefecture. He now has temperature distributions from seven summers in Uchiura Bay, an inlet on Kakasa Bay not to be confused with Uchiura (Funka) Bay in southern Hokkaido. Plots of air temperatures observed at nearby Maizuru versus the mean surface temperature in Uchiura Bay indicate a 2 to 3°C

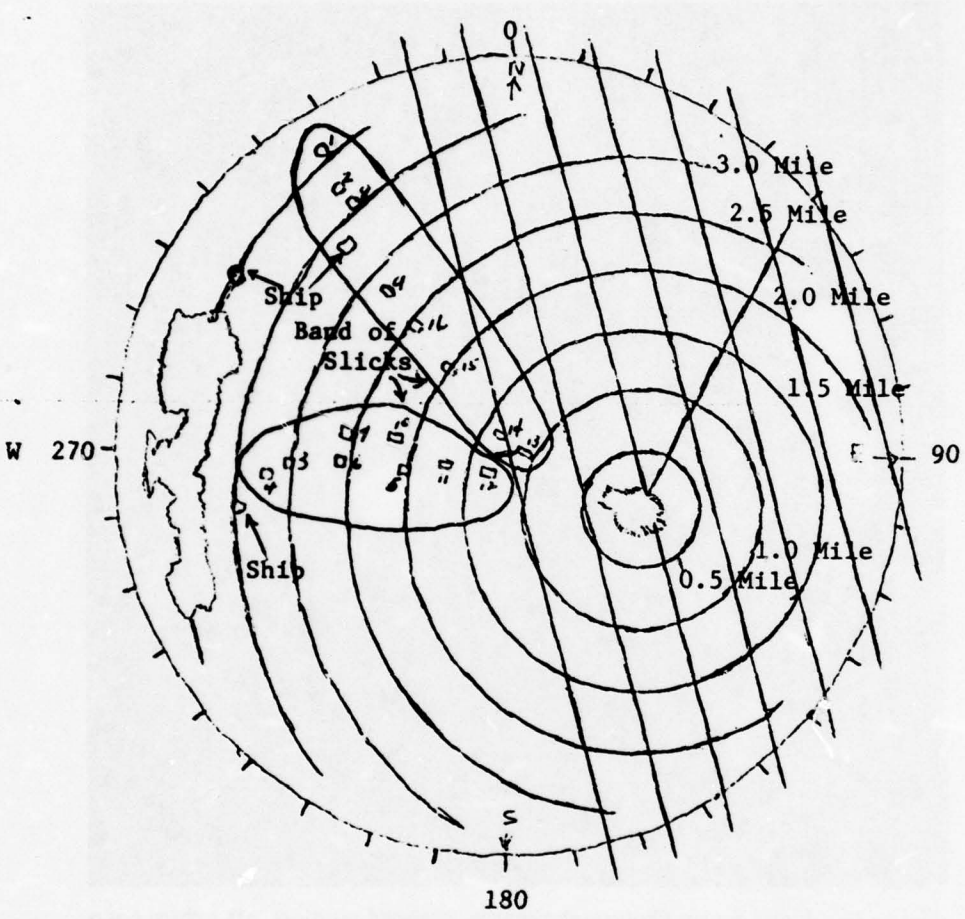

Figure 2B. Reversal of Figure 2A with explanatory information affixed.

temperature increase in the bay waters for corresponding air temperatures. So far there have been no observed correlations with changes in the biota of the bay.

The College of Agriculture publishes *Memoirs of the College of Agriculture of Kyoto University*. There are several series within the *Memoirs*: Entomology, Chemistry, Phytopathology, Botany, Genetical, Horticultural, Fisheries, Agricultural Economics, Plant Breeding, Forest Service (Agricultural Engineering), Wood Science and Technology, Animal Science, and Crop Science. The papers may be in English or German.

The late Professor Masayoshi Ishibashi was one of the earliest Japanese chemists to turn his attention to the chemistry of seawater. Many of his early analyses have been replaced with the introduction of a gamut of new and powerful analytical methods since World War II, but he was a pioneer and his death in late 1978 marks the passing of a generation of analytical chemists that attacked the problems of the composition of seawater with a high degree of analytical skill but methods that were frequently inadequate to the problems. Two of Ishibashi's students, Professor Taitiro Fujinaga, who occupies the Chair of Analytical Chemistry of the Faculty of Science, and Professor Tsunenobu Shigematsu of the Laboratory of Radiochemistry of the Institute for Chemical Research are continuing the traditions established by Ishibashi.

Professor Fujinaga is a member of the Science Council of Japan and of the International Union of Pure and Applied Chemistry (IUPAC) and is President of the Marine Biological Laboratory of Kyoto University, which operates the famous Seto Marine Biological Laboratory at Shirahama (see "Japanese Marine Laboratories" by Aubrey Gorbman, *Scientific Bulletin*, Volume 3, No. 2). In his career Fujinaga has turned his attention to many aspects of the analysis of seawater. Ishibashi made some of the first attempts to determine chromium in seawater, an interest continued by Fujinaga, who has published on the behaviour of trivalent and hexavalent chromium during coprecipitation with ferric hydroxide. He has also been interested in the occurrence of a variety of minor elements in sea weeds and coastal sediments. More recently he has been working on the development of electrolytic chromatography and coulopotentiography, described as a rapid electrolysis in a column electrode used for the preparation, separation, concentration, and estimation of trace or unstable (or both) substances. The method has been used for, among other things, the determination of 1 to 2 x 10^{-8} Molar cadmium, lead, and copper and traces of oxalate ions in strongly radioactive solutions; for the determination of plutonium in the presence of other metal ions, in the radiometric determination of thorium B, thorium C, and thorium C″. The methodology was reviewed by Fujinaga and S. Kihara in *Critical Reviews in Analytical Chemistry*, 6(3), 223-254, 1977.

Professor Shigematsu, although he leads the "Laboratory of Radiochemistry," carries out little or no research in radiochemistry other than the occasional use of radioactive tracers in analytical chemistry. This may seem surprising, but it is quite common for the names of laboratories in a Japanese university to have little to do with the actual research in the laboratory. His recent researches have resulted in publications on the spectrophotometric determination of chromium III and VI in seawater; the use of atomic absorption spectrometry with a carbon tube atomizer to determine lead and copper [lead concentrations of 1.7 to about 8 ppb (parts per billion) were found in Suruga Bay]. The carbon tube method has also been used to determine copper in seawater and shellfish. In seawater, concentrations of 0.0036 to about 0.014 ppm (parts per million) were found. In the shell of sea clams concentrations were 0.15 to 0.38 ppm, and in the soft parts concentrations were somewhat enriched; 0.43 to 8.3 ppm were found.

Shigematsu and his staff are also active in studying various coprecipitation phenomenon, including the coprecipitation of strontium and lead with hydroxyapatite, cadmium with aragonite, and cobaltous ions with calcium oxalate.

Shigematsu's laboratory has a staff of four and five graduate students. Other projects in the laboratory include the study of partition of elements such as zinc, manganese, and the rare earths between organic and inorganic fractions, using extractions with such solvents as ethylene glycol, cyclohexane, and zinc chloride. In some seawater 10 to 30% of the metals can be extracted into cyclohexane.

The *Bulletin of the Institute for Chemical Research* is published by the Institute. Vol. 55 was published in 1977.

During my previous stay in Japan I worked in 1971 with Dr. Akira Kawai in the Laboratory of Applied Microbiology of the Research Institute for Food Science. At that time he was interested in an experiment in which a small inlet on the Japan Sea Coast was being artificially aerated. Normally the inlet became stratified, especially in summer, stagnated, all the dissolved oxygen was consumed from the bottom water, and toxic and noisome hydrogen sulfide was produced. Otherwise it was an excellent site for shrimp culture. Kawai and his staff were following the changes in distributions of dissolved oxygen and nutrients brought about by pumping air into the deep waters of the bay. I learned that the air pumping was not very successful and the problem was eventually solved by deepening the inlet. A triumph of ocean engineering over chemical oceanography, but it was an interesting experiment.

Much of Kawai's efforts are now directed at the red tide problem in Lake Biwa described earlier. He is also consulting on the problem of red tide blooms of *Hornellia marina* in the Seto Inland Sea, where up to 300 red

tides have been observed in one summer. He and his staff are also carrying out studies of the nitrogen cycle in aquatic environments and on the release of ammonium nitrogen from the sediments of freshwater bodies. He is also working on various aspects of the biochemistry of the enzymatic reduction of trimethylamine oxide to trimethylamine, which is released during the spoilage of fish and is responsible for "fishy" odor.

Dr. Kawai, his assistant Dr. M. Sakaguchi, two graduate students, and an assistant comprise a small but busy and productive group working on interesting problems with a high degree of professionalism.

The institute formerly published a *Memoirs* series, but it is now combined with the ***Bulletin of the Research Institute for Food Science***, which is published annually and includes papers in Japanese and in English.

GOVERNMENT INDUSTRIAL RESEARCH INSTITUTE, CHUGOKU

Francis A. Richards

Superlatives come to mind frequently when considering things Japanese. Tokyo—the largest city with the highest cost of living in the world; Shinkansen, the "bullet train," the fastest in the world; the most rapid industrial growth in the world. Kyoto University has the most powerful electron microscope, and the world's largest tanker ships have been built in Japan. I am not sure that the hydraulic model of the Seto Inland Sea is larger than the U.S. Corps of Engineers' models of Chesapeake Bay and San Francisco Bay or not. But it may contain more water—about 5000 tons (I am used to the Research Vessel *Thomas G. Thompson* of the University of Washington; she displaces about 1400 tons). In any case the model is "most" impressive.

The Government Industrial Research Institute, Chugoku, 15000 Hiromachi, Kure City 737-01, Hiroshima Prefecture, is one of 16 research institutes within the Agency of Industrial Science and Technology (AIST), which operates as part of the Ministry of International Trade and Industry (MITI). The institute has three sections, the Coastal Environment Division under Dr. T. Saito, the Machinery and Metals Division under Dr. T. Fukuda, who is also director of the whole institute, and the Research Planning Section under Mr. H. Ihara.

The general mission of AIST is to assist industrial growth through research and development, including protection of the environment. Much of Japan's rapid industrial growth has been in the regions surrounding the Seto Inland Sea, and the Coastal Environment Division of the institute is concerned with the often conflicting aims of industrial development and protection of the environment. The environment of the Seto Inland Sea is particularly important to the Japanese as a region of extraordinary scenic beauty, commercial and pleasure boating, extensive fishing grounds and fish culture activity, and industrial enterprise. Large areas of the coast have been reclaimed by land fill, and three major bridge routes from the main island of Honshu to Shikoku across narrow parts of the sea are planned. All these considerations pointed toward the necessity for environmental pollution evaluation and prediction and detailed knowledge of the tides and currents of the sea. This is the general charge of the Coastal Environment Division, which has three sections: Dr. Norio Hayakawa leads the Coastal Hydraulics Section, responsible for hydraulic modeling; the Fluids Instrumentation Section under Dr. Saito is responsible for instrumenting the model; and the Environmental Chemistry Section under Dr. T. Shiozawa is responsible for chemical characterization of the prototype and for developing chemical techniques for the prevention of water pollution.

My principal interest was in seeing the model and learning about the environmental chemistry program. The Director, Dr. Fukuda, and Dr. Hayakawa, who arranged my visit and generally acted as my host, gave me a personally guided tour of the Seto Inland Sea model. Dr. Kayakawa is a graduate of Tokyo University and has a doctor's degree in civil engineering from the University of Minnesota, so explanations were knowledgeable and in excellent English.

The building housing the model is 230 meters long, 100 meters wide, and has an area of 17,000 square meters. Kure City is in a region of little tectonic activity. One end of the model rests directly on bed rock; so far there have been no problems with its stability.

The scale of the model is 1/2000 in the horizontal and 1/100 in the vertical, so there is a vertical exaggeration of 20. Even with the exaggeration one gets the impression of shallowness—the deepest part of the

model is slightly truncated and only about 2 meters deep. It reminds me of the comparison of the depth of the ocean with the thickness of the earth; if the earth were the thickness of a 3,000 page unabridged dictionary, the ocean would have a maximum thickness of about three pages. It is easy to think about the depth of the ocean, but the width of the ocean is a more impressive figure.

The vertical exaggeration makes the modelling of water flow somewhat difficult. The problem is partially solved by adding roughness elements (concrete blocks of varying size) in certain areas of high slope.

The topography of the model is based on 35 sheets of topographic maps on a scale of 1/50000 and contour lines every 2 meters. The basic charts were from the Hydrographic Office of the Maritime Safety Agency and they are updated from topographic maps from the Geological Survey and harbor planning maps from the Ministry of Transport. The specifications call for an accuracy of 2mm in the shallower parts of the model, which is constructed over a thick watertight barrier. The contours were inscribed on the floor of the model and color coded chopsticks were driven into the base to establish the contour lines. The form was then cast in concrete and finally finished with white mortar.

Tides are generated by three tilting wires that represent the connections between the Inland Sea and the Pacific Ocean at the north and south ends of Shikoku Island and with the Sea of Japan between Honshu and Kyushu islands. The time scaling is 1/160, so a day can be modeled in nine minutes.

The model is controlled and monitored from a control center, which commands the tilting wire and recirculating pump system that generates the tides. Tidal current and water level gauges placed at various points in the model are also monitored, recorded, and analyzed in the control center.

One of the main uses of the model is to study the fate of pollutants introduced from point sources–generally a river or stream. Pollutants are simulated by injecting the dye rhodamine-B, which can be photographed readily or determined quantitatively by spectrophotometry or fluorometry. Dispersal of the dye can also be photographed from eight gondolas hung from four overhead traveling cranes. The photographs can then be digitized and maps showing the trajectories of the injections are then computer generated.

Two overhead sampling stations, each 10 x 10 meters, can be lowered to any position above the model and a grid of syringe collected samples can be taken without disturbing the flow of water.

No attempt is made to model salinity distribution and the model is operated with fresh water. The amounts of salt that would be required to simulate seawater salinity would be enormous, and the action of the model would soon destroy any stratification that might be simulated. This is unlike the model of Puget Sound at the Department of Oceanography of the University of Washington, in which salinity is successfully modeled, but the model is on a scale a fraction of that of the Inland Sea model. Wind effects cannot be simulated on either model.

Several kinds of wave and water level gauges, current meters, and *in situ* colorimeters are in use, have been used, or are being developed. I was particularly interested in a fiber optics colorimeter that can be dipped into the model to determine dye concentrations. The cell length is about 1 cm (which gives a light path of 2cm because the light penetrates the cell length and is reflected back through it), so its resolution of dye distributions can be quite detailed.

In spite of its size–larger than three football fields–one is impressed by the sophistication of the model and its sensitivity in reproducing the prototype.

Comparisons with the prototype are made using data from a variety of sources, mainly the Marine Observatory of the Meteorological Agency at Kobe, the Fisheries Agency, and the Maritime Safety Agency. Some

observations are carried out by the Environmental Chemistry Section using a chartered catamaran type research vessel, but I got the impression that these were not survey type observations designed for comparing the model and the prototype.

After our walk around the model Dr. Fukuda said gently, we should rest. You must be tired. We have just walked over 2000 kilometers!

The Environmental Chemistry Section is studying the water quality of the Seto Inland Sea and the release of pollutants from the bottom sediments. They have collected sediments from some 400 stations using a grab sampler. The samples are analyzed for carbon, nitrogen, phosphorus, zinc, copper, manganese, and particle size distributions. Maps have been prepared showing the distributions of areas of reducing sediments and the Eh of the bottom waters and of the upper layer of the sediments. The fine grained sediments are rich in organic carbon and nitrogen, zinc, and copper. Reducing sediments are found in Osaka Bay and Beppu Bay and are low in manganese.

An interesting part of the Inland Sea is a deep (ca. 70 meters) depression in Beppu Bay. A strong thermocline develops from August to November, the water becomes anoxic, and hydrogen sulfide appears. Observations of soluble and particulate iron, manganese, and turbidity show a very large and sharp peak in the turbidity at the oxygen-sulfide interface; the layer has been found to be rich in particulate manganese and iron. The observations are consistant with those in the Black Sea and in Lake Nitinat, a marine fjord on Vancouver Island, British Columbia, Canada.

In addition to seeing the model and visiting the Environmental Section, I was given a brief tour of the Corrosion Control Section by its head, Dr. K. Kudo, whose academic background is in electrochemistry. The main concern of the section is the study of the corrosion of metals under seawater. At the basic electrochemical level they are studying reactions between various iron-based alloys and chloride ions. They are also participating in the Japanese OTEC (Ocean Thermal Energy Conversion) program and are studying the problems of corrosion of heat exchanger systems and the metals used in them, especially titanium and copper based alloys. (The Japanese intend to use titanium in their systems because of its high corrosion resistance.) The section is also interested in biofouling. By the fall of 1978 they had made only laboratory studies but planned to begin studies of the biofouling and corrosion of heat exchangers in the sea in the near future.

Experiments were being carried out in the electrochemical laboratory to determine the anodic polarization curve of titanium in various acidic solutions to help understand the dissolution behavior of the metal. A Nichia potentiostat was being used to control a constant electrode potential. The laboratory also has a thin film ellipsometer that they want to use to measure thin films formed on metal surfaces during corrosion and biofouling. The instrument was developed in the United States and was first used to measure antibodies formed when organisms are exposed to toxins. It is sensitive to a few angstroms.

High temperature corrosion of metals in various gases is the subject of research in another section of the Institute, which is equipped to carry out tensile strength and creep tests on various carbon and stainless steels in atmospheres of hydrogen up to 100 kilogram per square centimeter at temperatures up to 500°C. Tensile strengths in air can be measured up to 200 tons.

Other experiments are being carried out for the formulation and testing of corrosion resistant coatings that can be applied and will harden under water.

Like many of the newer governmental laboratories, the Government Industrial Research Institute, Chugoku, is housed in attractive, modern, functional and well maintained buildings and has excellent equipment. Among the equipment I was shown, mostly in the Corrosion Control Section, were:

1. A Cahn electromicrobalance system used to determine the evolution of carbon dioxide, carbon monoxide, and hydrogen from mild steel.
2. A gas measuring system to estimate the hydrogen content of steels. Corrosion is frequently associated with hydrogen evolution, and hydrogen acts as an accelerating agent in steel corrosion. The steel is heated by high frequency radio waves to 1000°C and the evolved gas is analyzed chromatographically.
3. A Nikon differential interference microscope with a heating stage, used to observe surface morphology.
4. A spark spectrograph for the estimation of iron, molybdenum, phosphorus, silicon, chromium, aluminum, manganese, copper, nickel, and zinc in steels.
5. A grating infrared spectrophotometer.
6. X-ray diffraction equipment for determining crystalline structures.
7. A fluorescent X-ray spectrometer.
8. A JOEL JSM 50A scanning electron microscope.
9. A JOEL JXA 50A electron probe microanalyzer.

The Institute has started a publication series, *Reports of the Government Industrial Research Institute, Chugoku.* The first and second numbers were published in July 1976 and July 1977. The papers are in English or Japanese.

HOKKAIDO UNIVERSITY
FACULTY OF FISHERIES AT HAKODATE

Francis A. Richards

BACKGROUND OF THE UNIVERSITY

Hokkaido University traces its origin to 1872, during the Meiji period, when Japan broke out of the feudal bonds of the Tokugawa Shogunate and embarked on a course of instant modernization. Hokkaido University became, and remains, a leader in agricultural and fisheries sciences.

The present Faculty of Fisheries began as the School of Fishery attached to the Sapporo Agricultural College, established in 1907. Various administrative and name changes followed, and the Faculty of Fisheries assumed its present form in 1949.

THE FACULTY OF FISHERIES

The Faculty, which corresponds to a college within an American university and is headed by a Dean, is departmentalized; each department consists of a group of Chairs, and the department chairmanship rotates annually:

Department of Biology and Aquaculture,
- Chairs: Marine Zoology, Marine Botany, Embryology and Genetics, Physiology and Ecology, Planktology, Freshwater Fish Culture, Marine Culture.

Department of Food Science and Technology,
- Chairs: Food Chemistry I and II, Biochemistry, Marine Food Technology, Microbiology, and Training Factory for Food Processing.

Department of Chemistry,
- Chairs: Biopolymer Chemistry, Chemistry of Fish Oil, Marine Chemistry, Analytical Chemistry, Chemical Engineering.

Department of Food Science,

Subcourse of Science of Fishing Ground
- Chairs: Principles of Fishing Ground, Oceanography and Meteorology, Biology of Fish Population, Fishing Navigation.

Subcourse of Fishing Technology
- Chairs: Operation Technology of Fishing, Fishing Gear Engineering, Mechanical Engineering for Fishing, Instrument Engineering for Fishing, Engineering of Fishing Boat, Fishing Boat Seamanship, Fisheries Business Economics.

The Research Institute of North Pacific Fisheries has divisions of Fisheries and of Oceanography.

Staff from the Faculties of Literature and of Education are resident at Hakodate for teaching basic courses, but the first one and a half years of undergraduate education are at the General Education Department on the Sapporo Campus.

BUILDINGS

The main hall of the faculty is a new six-floor building with administrative offices and laboratories. Other buildings house a training factory for food engineering, the Fisheries Museum, the Research Institute of North Pacific Fisheries and the library.

SEAGOING PLATFORMS

The Faculty operates three fisheries training and research vessels. *The Oshoro Maru*, a stern trawler, 1180 gross tons, built in 1962, which is also equipped for long line and drift net fishing. She has oceanographic, chemical, and biological laboratories. The *Hokusei Maru* II is 273 gross tons, steel hulled, and was built in 1957. A day cruiser, the *Ushio Maru*, 98 tons, was built in 1971.

It may surprise American marine scientists to learn that the senior officers of the *Oshoro Maru* and the *Hokusei Maru* are considered faculty members and have academic titles. Captain T. Fujii of the *Oshoro Maru* is a Professor, the Chief Officer is an Associate Professor, the First Officer is an Assistant Professor, and the Second Officer and Chief Engineer are Instructors. On the *Hokusei Maru* the Captain is an Associate Professor, the First Officer is an Assistant Professor, and the Second and Third Officers are Instructors. Some of these officers participate in research and publish scientific papers in their own right.

OTHER FACILITIES AND STATIONS

Other facilities of the faculty are the Usujiri Fisheries Laboratory at Usujiri, Minami-Kayabe; Toya Limnological Station, Tsukiura, Abuta-gun; Nanae Fish-Culture Experimental Station at Nanae, Kameda-gun. The Faculty of Science maintains a teaching laboratory and algology research laboratory at Muroran, on Funka (Uchiura) Bay, which is an important region for the culture of a brown alga of the genus *Laminaria*, the widely used *kombu* of Japanese cuisine.

The faculty publishes the quarterly *Bulletin of the Faculty of Fisheries of Hokkaido University*, in both Japanese and English, and occasional *Memoirs of the Faculty of Fisheries, Hokkaido University*. *The Data Record of Oceanographic Observations and Exploratory Fishing, Faculty of Fisheries, Hokkaido University* carries preliminary data from oceanographic, biological and exploratory fishing cruises of the training-research ships.

PLANKTOLOGY LABORATORY

The Chair of Planktology is held by Professor Takashi Minoda and Dr. Akito Kawamura is Associate Professor. The research in the department is devoted to studying all aspects of the role of both phytoplankton and zooplankton in the marine food chain. In Japan the practical applications of such research are obvious, but nonetheless good basic research is being carried out. Systematics, physiology, ecology, and zoogeography are included in their program. Professor Minoda is now involved in river mouth ecology because these special environments have been studied little, but they are biologically important because some salmon larvae appear to spend one or two months in such environments before going to sea. The availability of food in these environments is unknown, but it probably depends in part on seasonal changes in hydrography and hydrology. Spring snow melts produce fresh water lenses at river mouths and these result in high phytoplankton productivity. In April and May high euphausid populations succeed, and these are important food for salmon larvae. The euphausids are mostly cold water species, and physical oceanographers have a rule of thumb that there will be no salmon larvae in water warmer than 15°C. This may be true, but the biologists suggest that the limitation is a result of the availability of cold water zooplankton food species suitable for the larvae. Funka Bay,

on the Pacific Ocean side of Hokkaido, contains cold, Oyashio water in the winter and is rich in the zooplankton species *Calanus plumchrus, Calanus cristatus,* and *Euphausia pacifica.* After June, there is a change to small, warm water species that are not suitable food for salmon larvae. Funka Bay is also important in the life cycle of some Alaska pollock, *Theragra chalcogramma,* stocks, which enter the bay in February and March and breed there. The larvae remain in the bay until June.

Photosynthetic activity strips the upper 30 m of Funka Bay of phosphate and nitrate in March and microflagellates are abundant from May to November. Monthly surveys of the bay are made, with observations of temperature, salinity, oxygen, phosphate, silicate, nitrate, nitrite (ammonia has recently been added to the list of observations), chlorophyll by fluorescence, phytoplankton, and zooplankton counts. So far fish eggs and larvae have not been counted. The program of observations includes determining the ratio of net plankton to nannoplankton (the latter retained by a 44 micron filter). The net plankton, mostly diatoms, is most important during the spring bloom. It is assumed, however, that the zooplankton biomass depends basically on the biomass of nannoplankton.

Mr. Mueno, graduate student, is studying the timing of phytoplankton blooms in local waters, including Funka Bay. The studies are supported by daily samplings in early spring as well as by laboratory studies of diatom cultures. From August to February, Funka Bay is filled with waters from the Tsugaru warm current (Tsushima Current), which enters the region from the Japan Sea. In February these warm waters are replaced by Oyashio waters from the north. Mueno is making what he calls "growth potential bioassays of water" by incubating various diatom species for 15 days at 5°C in different kinds of waters. In all cases, Funka Bay water or a mixture of Funka Bay and Oyashio waters is better than straight Oyashio water for the growth of species characteristic of the Oyashio Current. Presumably this is because of the influx of Urappu River water, rich in silicates, into the head of the bay. The diatoms used for the bioassays are *Coscinodiscus longissima, Chaetoceros atlanticus, C. concavicornis, C. debilis, C. decipiens, Biddulphi aurita,* one Centrales species, and one Pennales species.

An immediate objective of the research on river mouth ecology and in Funka bay is in the improvement of salmon runs. The Urappu River has a hatchery for chum salmon and some successful trials have been carried out in Honshu on impounding salmon larvae at river mouths before releasing them to their migrations in the open ocean. The impoundment greatly improves the chances for their successful return and for the return of larger and more vigrous fish. The objective of the research is better to understand these environments and their relationship to the life cycle of the salmon. The work is funded by the Fisheries Agency.

Significant components of the zooplankton in the northern North Pacific and the Bering Sea are the Appendicularia, particularly the boreal species *Oikopleura labradorensis.* It is an important food item for juvenile sockeye salmon in the North Pacific and for plaice in the North Atlantic. The animals are collected in large numbers in zooplankton net tows. The laboratory has collections from over the past 20 years from the Bering Sea, although the collections have been confined to the summer season. The collections are being analyzed for geographical distribution, annual variations, and developmental stages, of which there are five based on gonad development. The collections have been made from 150 m to the surface using a NORPAC (0.35-mm mesh) net. Population densities (animals per m^2) are determined for 5° squares and attempts are being made to correlate them with temperature and salinity. As with many plankton species, the distribution is patchy, and they may be relatively rare or abundant under similar environmental conditions. The southern limit of the animals is about 40°N latitude, and, in the Bering Sea and northwest Pacific, they are most abundant east of the Kurile Islands and between 165 and 170°N in the southern Bering Sea.

The Appendicularia (larvacean) are wonderful little animals in that the body secretes a mucous structure, or house, that is larger than the animal and within which the animal can move freely. The house has net or grid-like structures that admit particles small enough for the animal to injest but excludes particles that are too large for food. These nets become clogged about six times a day, whereupon they are abandoned and another house is

secreted. This process has been described for other species of Appendicularia by Alice Alldredge of the University of California, Santa Cruz (*Scientific American*, 235, pp 94-100, 1976), but *Oikopleura labradoriensis* is considerably larger than the species she has studied, and the discarded houses might well be an important food item for other predators. This is difficult to assess because the houses are so fragile that they are never observed in net tow samples. They have, however, been collected in jars by SCUBA divers. *Oikopleura labradoriensis* itself feeds on microplankton.

Soshi Hamaoka is studying Cyclopoid (Oncaea) copepods. Although there have been many studies of the Calanoid copepods, there have been few studies of the cyclopoids, and those studies have been largely taxonomic. There have been a few studies of their distribution in tropical waters but practically none in the polar seas. Mr. Hamaoka is investigating their zoogeography in the Pacific. The cycopoid copepods are too small to be taken by the usual 0.35-mm mesh zooplankton net, so Hamaoka uses a 0.1-mm mesh net. Horizontal tows are made using an MTD (MTD for Sigeru Motoda, former professor of planktology at Hakodate) system–ten closing nets towed horizontally simultaneously. He also uses vertically closing nets; in the Bering Sea he sampled the intervals 0-200, 200-500, 500-1000, and 1000-2000 meters. He has sampled off Hokkaido and at 10°, 15°, 40°, and 50°N along 155°W. The sampling in the Bering Sea is generally from the *Oshoro Maru*. He also has collections from 0-200 and 200-500 m at about 20 stations occupied in the Tasman Sea by the *Kaiyo Maru* of the Fisheries Agency in 1970-71. Samples were taken at 155 stations in the Bering Sea by the *Hakuho Maru* in 1969. The main purpose of his studies is to describe vertical and horizontal distributions of these copepods in the open Pacific and in Funka Bay, but seasonal and annual changes are important, and toxonomic studies are being carried out. Gayle Heron of the University of Washington has described some 20 new species of the genus *Oncaea* from the Antarctic; Hamaoka has now found about 60 species, of which 10 or more are probably new.

The immediate interest in Antarctic krill, *Euphausia superba*, as a potential commercially exploitable, renewable marine resource has stimlated basic research on such matters as their life cycles, sex differentiation, reproductive and growth physiology, and the effects of water mass movements on breeding and distribution. More distinctly applied fisheries questions such as body lengths, the composition of populations by year class, biomass distribution and estimation, and breeding grounds are important because of the two roles Antarctic krill play–as the major food of Antarctic baleen whales and as a potential fishery in itself.

Conventional sampling designed to help answer these questions is done by various kinds of netting and trawling. Another method has been adopted by Associate Professor Akita Kawamura–he is studying the euphausid contents of whale stomachs. This limits his sampling to the time of the Antarctic whaling season, December to March. Although there are other obvious limitations to this method of "sampling" the krill, it does yield fairly direct information on the relationship between the life cycles of the kirll and the feeding habits of the whales and should help answer the question of whether or not the whales feed selectively.

In the Antarctic younger krill, one to two years old, are caught, but in the Bering Sea whales feed on fully grown krill–apparently there is a different distribution by ages in the Antarctic. Dr. Kawamura suggests that there probably are reproductive stocks of krill in each of the Indian, Pacific, and Atlantic sectors of the Southern Ocean. The role of water mass movements in the distribution of krill stocks needs to be known for properly managing the krill fishery, which many scientists and fishery experts are confident will be developed.

The Research Institute of North Pacific Fisheries is headed by Professor Seikichi Mishima, who also heads the Division of Fisheries within the Institute. There is also a Division of Oceanography, headed by my old friend Professor Jiro Fukuoka, who for several years was associated with the Instituto Oceanographico, Universidad de Oriente, Cumana, Venezuela, where he carried out research on the physical oceanography of the Caribbean Sea.

As the name implies, the Institute is ultimately concerned with fisheries research, but this includes programs in ecology, marine biology, and physical, chemical and biological oceanography. As well as fish and

squid studies, they are also working on the biology and ecology of sea birds and mammals, the basic food chain, and the whole ecosystem in the Bering Sea.

In the summer of 1978 the *Oshoro Maru* and the *Hokusei Maru* worked in the Bering Sea and northern North Pacific. Physical oceanographic measurements in the area 39 to 45°N, 175 to 180°W are intended to help understand the water mass and current regime in the area of the Emperior Seamounts, which the Japanese consider to be an area that may be favorable for the development of a high-sea fishery. Possible commercial species in the area are unknown and intensive experimental fishing with gill nets of 10 different mesh sizes is part of the program. Also of basic interest in the food chain problem are studies of upwelling carried out by Dr. Fukuoka in the Bering Sea, 53 to 56°N, 175 to 180°W.

The objective of the physical oceanographic program of the institute is to understand the relationship between oceanographic distributions and processes and biological productivity in the North Pacific. Professor Fukuoka is particularly interested in upwelling phenomena that are not associated with coastal wind systems. The North Pacific north of the Subarctic Boundary (about 40°N. latitude) and the Bering Sea are characterized in summer by a temperature minimum at about 100 meters; the cold water is associated with relatively high nutrient concentrations. Fukuoka theorizes that the counterclockwise circulation in the Bering Sea causes this water to dome upward into the photic zone so that photosynthesis can take place and add to the organic enrichment of the sea. During the summer 1958 cruise of the *Oshoro Maru*, Fukuoka cooperated with scientists from the University of Alaska aboard the R. V. *Acona*, investigating his theory. The *Oshoro Maru* carried out physical oceanographic observations and the chemical work was done aboard the *Acona*.

Another type of upwelling occurs along the northwest coast of Hokkaido. This is shown on infrared imagery made on 23 July 1977 by a NOAA satellite. The image shows a cold band just off the coast and parallel to it. The temperature distribution has been verified by simultaneous observations made from the *Tansei Maru* of Tokyo University. The feature appears to be present every summer, but the other seasons are unknown. The upwelling is not wind driven but apparently arises from the difference in the thermal structures of the Japan and Okhotsk seas. There is, at least in summer, a dynamic high in the Sea of Japan, a low in the Okhotsk sea. As water leaves the Japan Sea, it meets a south-flowing current; combined with the effects of the Coriolis force, this causes the upwelling along the coast and consequent nutrient enrichment of the photic zone.

One of the graduate students in physical oceanography, Mr. Masaaki Suzuki, is studying the relationships between physical and biological processes that result in red tides (*Akashio*), specifically the red tides in Tokyo bay, but the model he proposes is a general one. It is based on the different rates of horizontal diffusion in a two-layer system. Zooplankton migrate into the upper layer at night, graze on the phytoplankton, and retreat to the lower layer in the day. Horizontal diffusion rates in the upper layer apply to both phytoplankton and zooplankton at night, but only to the phytoplankton in daytime. Thus nutrients, which are taken up by phytoplankton and excreted by zooplankton, become differentially distributed, and the proper balance among diffusion and mixing rates can cause an outburst of organisms, or red tide.

Another project is concerned with the measurement of turbidity in Funka Bay. It is being carried out by Mr. Hideo Miyake, who has devised his own turbidimeter. His measurements in Funka Bay are limited to a little over 100-m depths, but the institute hopes to buy an American made alpha meter, which is good to about 200 meters and would permit deeper measurements in the open ocean. The Funka Bay measurements are being correlated with thermograph temperature observations and discrete-depth salinity observations. In September 1976, a turbid layer about 10 meters thick was observed in the bottom water, but in May 1977 there was also a highly turbid layer centered at about 20 to 30 meters. Inorganic versus organic components of the particulate matter are being estimated from ignition losses.

Another line of investigation of turbidity is being carried out by Dr. Masahiro Kajiwara along with Mr. S. Nakaya of the Department of Chemistry. They are attempting to investigate the properties of "marine snow"

(seston or detritus). A substance at least superfically similar to "marine snow" is being produced artificially in the laboratory. Filtered seawater is circulated upward in a tube and downward through a surrounding concentric tube in a water-jacketed container held at 10 to 15°C. The convective circulation is driven by a small heater under the central tube. After three to four days "marine snow" is formed and with further circulation the particles tend to grow. One of the objectives of the experiments is to understand the relationship between the growth rate and water temperature and ultimately to understand the relationship between temperature and the distribution of natural "marine snow."

Another project of Mr. Miyake is the study of temperature fine structure using thermographs and current meters attached to set fishing nets in inland waters. Both horizontal and vertical fine structures are of interest, but the work lacks the sophistication of the fine structure and microstructure observations being made in western countries.

Professor Masakichi Nishimura occupies the Chair of Analytical Chemistry in the Department of Chemistry. His Associate Professor, Dr. Shizuo Tsunogai, who studied under Professor Yasuo Miyake, is well known in the United States, having spent considerable time at both Woods Hole Oceanographic Institution and Scripps Institution of Oceanography. This is a very active laboratory with one instructor and 11 graduate students, six in the Ph.D. course, the others in the Master's course. The research topics cover a wide range of marine chemistry, geochemistry, environmental radiochemistry, and chemical oceanography.

One project is concerned with the relationship between the chemistry of Toya hot spring and the volcanic activity of Mount Usu, which erupted violently in August 1977. Mercury and boron were monitored in the hot spring. There was a minimum in the mercury content, normalized to the chlorine content, in October 1977, and a maximum was reached in December.

Professor Nishimura has made over 500 mercury determinations in ocean waters around Japan. The distribution is almost uniform both horizontally and vertically. The observed concentrations, 5 to 6 nannograms per liter, are 1 or 2 orders less than other workers have reported and may represent a base line for unpolluted ocean water. The higher values reported by other workers may well be the result of contamination from reagents or sampling equipment.

Other projects in Professor Nishimura's laboratory include investigations of organic complexes in seawater using a copper ion specific electrode. Total and chloroform extractable copper in seawater are also being determined by atomic absorption spectrophotometry. The organic fraction amounts to about 7% of the total in the Indian Ocean but about 20% in Funka Bay. Other graduate students are attempting to improve the methods for determining phosphate and nitrate in seawater. One student is investigating the distribution of lead-210. The sediments of the Japan Sea contain about 2.5 disintegrations per (cm^2/year), but the concentration is about twice that in the region of the Bonin Islands. It is suggested that the ^{210}Pb has a continental source and ocean sediments may be a negligibly small source.

Other projects are concerned with the migration of manganese in pelagic sediments, the effects of silicate on the determination of phosphate in seawater, the determination of lead, thorium, and radium in deep-sea sediments and manganese nodules and the determination of diffusion coefficients affecting radium diagenesis.

Sediment traps are being used to investigate the flux of particulate matter from the surface to the deep ocean. Radioisotopes are being used to trace the settling particles. Settling rates of the order of 1 meter per day have been observed in the upper layers of the open ocean; rates may be higher in coastal areas.

The analytical chemistry laboratories are crowded but rather well equipped. I was shown an Hitachi RAH403 2100-channel analyzer, an Aoki anticoincidence counter and universal scalar, a Jarrell Ash carbon rod atomic absorption spectrophotometer and good OV-VIS spectrophotometers and pH meters.

HOKKAIDO UNIV. FACULTY OF FISHERIES – FRANCIS A. RICHARDS

My general impression of the Faculty of Fisheries is that it is a center of high quality research and graduate training. As the name implies, the research is strongly application oriented, but it is well understood that mission directed research must rest on a solid base of fundamental research. The faculty and graduate students are up to date with current methods and the literature. So far as I could judge, the research is of generally high quality and the publication record excellent.

HAKODATE MARINE OBSERVATORY

Francis A. Richards

The Japan Meteorological Agency maintains, as part of its Marine Department, marine observatories at Hakodate, Maizuru, Kobe, and Nagasaki. The central Tokyo department serves as a fifth observatory. Each of the five operates a research-survey ship, and each has five divisions: Administration, Oceanography, Forecast, Maritime Meteorology, and Weather Observation. Each occupies a specified grid of oceanographic stations generally four times a year, and special cruises and special operations may be carried out from time to time.

The Hakodate Observatory under the direction of Dr. Masashi Yasui has much the same mission as the other observatories, with the forecasting and weather observation functions being rather routine, while the maritime meteorology and oceanography divisions are somewhat more research oriented.

Forecasting is based largely on sea surface temperature anomalies. The objective is to forecast oceanographic conditions as much as five to six months in advance. Historical data on sea surface temperature anomalies and the anomalies for the months preceding the forecast are used. The observatory has no computer, so the methods are largely manual.

The network of stations occupied by the *Kofu Maru* lies east of northern Honshu and Hokkaido; the ship also makes a cruise into the Okhotsk Sea once a year, usually in July. Routine observations include temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, ammonia, total phosphorous, chlorophyll *a*, phaephyton, and pH. At a few of the stations there are also observations of tar balls, floating pollutants, and petroleum hydrocarbons in surface water. In addition, samples for heavy metal determination are collected from the surface and 1000 meters at two stations.

The Hakodate Observatory differs from the other observatories in one important respect: it is also charged with sea ice prediction for the Okhotsk sea. The work is under the direction of Mr. Masaomi Akagawa and is very important to the function of fishing and other commercial ships. The goal is to predict the date of arrival of sea ice off the coast of Hokkaido, its departure date, and the extent of the ice cover. As with the oceanographic forecasts, the predictions depend on statistical methods and historical data.

COLLOQUIUM ON AQUATIC ENVIRONMENT IN PACIFIC REGION, TAIPEI, JAPAN

Francis A. Richards

The Golden Jubilee of Academia Sinica of the Republic of China was marked by the convening of the Colloquium on Aquatic Environment in Pacific Region in Taipei, in August, 1978. The colloquium was followed by technical field trips and visits to the National Taiwan University. The colloquium was sponsored by SCOPE, the Scientific Committee on Problems of Environment, a committee under the umbrella of the International Council of Scientific Unions (ICSU). Cosponsors were the Institutes of Botany, Chemistry, and Zoology of Academia Sinica and the Institute of Oceanography of National Taiwan University (NTU). Participants came from the Republic of China, Japan, the United States, Canada, and the United Kingdom. Greater participation was anticipated from southeast Asia but was not forthcoming. The colloquium was opened by a welcoming address by Dr. S. L. Chien, President of Academia Sinica, an organization that was founded in Nanking in 1928 and moved to Taipei at the end of 1948. The Academy now consists of 11 institutes and three more are planned. The Institutes of Chemistry and Zoology are both active in research in the aquatic environment. Professor Jong-Ching Su of the Institute of Zoology was Chairman and Professor Tsu-Chang Hung of the Institute of Chemistry and the Institute of Oceanography was Executive Secretary of the Organizing Committee.

A departure from the planned program was forced by the late arrival of the scheduled first invited lecturer, Dr. Edge B. Worthington, lately the Scientific Director of the International Biological Program. His place was taken by Dr. Charles R. Goldman of the Division of Environmental Studies of the University of California, Davis. Dr. Worthington arrived later and gave his talk, which was the real keynote of the meeting. In it he summarized the role of fresh water on the social and economic progress of mankind. He began by noting the increasing emphasis on inland water research as reflected by the number of relevant papers at the last two Pacific Science Congresses. There were very few such papers at the 11th Congress in Japan in 1966 except for those from Japan; again at Canberra in 1971 there were few contributions on inland waters, although there was an emphasis by the Russians on the effects of rivers on the productivity of coastal waters. But at the 13th Congress in Vancouver, 1975, there were some 60 papers on inland waters, 20 on aquaculture, 16 on the growth, physiology, and genetics of fishes, and 9 or 10 on pollution, river control, reservoirs, hydroelectric schemes, etc. [It should be noted that a plenary meeting and four synposia on Fresh Water Sciences are planned for the 14th Congress to be held in Khabarovsk, Siberia, in 1979 (F.A.R.).]

Enriching his talk with examples from his extensive experiences in Africa, Dr. Worthington discussed the interactions of the hydrological cycles with plants, animals, and man. He touched on the problems of conservation, wise use, changing water supplies (floods and draughts), management of water supplies, and the different quality of water required for differing uses. Some of the hazards in water use, particularly diseases carried by water, were mentioned. He mentioned AQUA, a project of the International Society of Limnology under which a list of key aquatic habitats is being developed. The habitats are designated for permanent conservation as representative types of special scientific, aesthetic, educational, or economic importance. The list now contains entries from 16 countries surrounding the Pacific and has already helped to avoid some undesirable developments.

Professor Goldman discussed the special properties, processes, characteristics, and uses of estuaries and the hazards presented to them by mismanagement and misuse. He and Worthington both mentioned the effect of overuse of river waters, specifically the Nile and the Colorado, and the resulting detrimental changes to the

estuarine environments. Estuarine systems are physically and biologically complicated and they are generally biologically rich. But because they are frequently population centers, subject to pollution, and are used for waste disposal, they require intelligent scientific management if much of their usefulness is not to be destroyed.

The contributed papers of the colloquium were given at sessions on A) Physical and Geophysical Studies, B) Geological Studies, C) Biological Resources and Environment and D) Water Resources and Pollution. Although pollution is mentioned in the title of session D only, there were papers directly on or touching on pollution problems and effects in all the sessions–in fact, few of the papers did not address some aspect of this topic.

The first contributed paper of the colloquium was by Dr. T. Y. Chu of the Institute of Oceanography, National Taiwan University (NTU), on the oceanography of the Kuroshio Current around Taiwan. The paper summarized Taiwan's investigations of the Kuroshio Current since 1965. The paper described the temperature, salinity, and density distributions and current speeds and directions. The current has maximum speeds of 95 cm/sec and extends downward to nearly 1000 m; 1200 meters has been used as a reference level for geostrophic calculations. The current is warm–surface temperatures are up to 28°C in winter. There is a subsurface salinity maximum at around 100 to 150 meters, and the water masses are definitely stratified–a highly variable, warm, low-salinity layer overlying the Kuroshio water proper at 100- to 150- meter depths. A middle water, at depths of 600 to 800 meters is evident on the temperature-salinity diagrams. The middle water characteristically has a temperature of 6.5°C and a salinity of 34.2% and comes from the north. The deep water, below 800 meters, is colder (1.38°C) and a little more saline = 34.73%.

H. Nakata and T. Hirano of the Ocean Research Institute of the University of Tokyo discussed transport and diffusion in the Seto Inland Sea, Japan. The investigation was based on a drift card study during which 200 to 400 plastic cards were released from each of 30 different points in the Inland Sea system. In all 10,000 cards were released and around 35% of them were recovered.

The Inland Sea is surrounded by the Japanese Islands. It supplies some 37% of Japan's coastal fisheries (400,000 tons per year), contains important spawning grounds, and is the site of much of Japan's aquaculture industry (260,000 tons per year). It is also surrounded by tremendous industrial development and receives significant quantities of pollutants–an average discharge of chemical oxygen demand of 1420 tons per day has been observed. It also is afflicted by around 300 "red tides" each year–a red tide being an overgrowth of dinoflagellates that may be damaging to other marine life by their toxicity or by exhausting the oxygen supply. Such outbreaks are frequently associated with calm periods and weak circulation is apparently related to them.

Charts of the recoveries of the drift cards were prepared for recoveries within five days of release, 10 to 15 days, and from 15 to 30 days. Cards from the southwestern part of the sea tended to drift to the west, those from the northeast tended toward the east, but there were areas from which there was little movement even after 30 to 60 days, indicating poor circulation and near stagnation. Average drift speeds and variance in the distance drifted were used to calculate horizontal diffusion coefficients of the surface water. In the summer the cards from the western part of the sea drifted at 3 to 5 cm/sec toward the west; in winter they drifted eastward at 6 to 8 cm/sec when wind speeds were 2 to 3 meters/sec. Bottom and mid-depth drifters are being experimented with, but no clear picture of the diffusion in these layers has yet developed.

Richard S. Lu reviewed geophysical research in the western Pacific in very general terms and discussed the Taiwanese participation more specifically. In 1975 there was a Republic of China–United States–Philippines joint geophysical cruise aboard the R. V. *Chiu Lien* of the Institute of Oceanography of National Taiwan University. The operations were in the offshore areas of Taiwan and Luzon and included bathymetric, seismic, magnetic, and gravity observations. It was concluded that the China Basin was formed by sea-floor spreading and since the middle Miocene there has been subduction of the South China Sea plate at the Manila Trench. The Luzon island arc system thus approached Taiwan along with the northwestward movement of the Philippines Sea plate. Ju Chin Chen of the Institute of Oceanography, NTU, discussed some of the geological aspects of the western

Pacific area. Basalts from the Deep-Sea Drilling Project (Leg 31, sites 292, 293, and 294) in the Philippine Sea have been studied chemically. Also, materials from gravity cores and dredgings from water depths of 2900 to 5800 meters have been examined using x-ray diffraction and atomic absorption analyses. Most of the sea floor is covered by red clay. At one site 210 meters of red clay were penetrated, 150 meters at another. The sediments are generally poorly sorted. The grain size distribution, mineralogy, and chemical analyses of the sediments were presented in the paper.

Eleven manganese nodules were dredged from two locations, one 2900 meters deep, the other 5700 meters deep. The nodules contained 16 to 23% total iron, 16 to 34% manganese, 1500 to 3000 ppm of nickel, 825 to 1940 ppm of cobalt, and 13 to 20 ppm of chromium. Thus they are richer than the Philippine Sea pelagic clays in iron, manganese, nickel, copper, and cobalt, but they are poorer than the sediments in chromium. Dr. Chen estimated the rate of accumulation of red clays in the Philippine Sea to be 5mm per 1000 years.

Y. M. Chiang, Institute of Oceanography, NTU, gave an interesting and well-illustrated lecture on the coastal environment of Taiwan. Subject to erosion and deposition by monsoon and typhoon driven waves, there are many cliffs, wave-cut arches, stacks, mushroom rocks, and sand dunes along the north coast. There are tidal flats, offshore bars, spits and lagoons along the west, emergent limestone platforms in the south, with very high cliffs, long beaches, and sand dunes along the east. Tidal effects, pollution of the coast, and the littoral populations were summarized.

Professor Emeritus Koji Hidaka, world-famous Japanese pioneer in theoretical physical oceanography, was an invited lecturer and discussed the theoretical determination of the surface contours of the oceans on a rotating globe. The highly mathematical treatment included the effect of the density of seawater on the wind-produced surface forms. The elevations of the sea surface contours above a particular level surface were calculated for two oceans, one bounded by 0° and 60° meridians, the others by 0° and 180° meridians, corresponding to the Atlantic and the Pacific.

Professor Tsu-Chang Hung, who has his Ph.D. in Chemistry from the University of Minnesota, summarized observations of primary productivity, chlorophyll *a*, temperature, salinity, and dissolved oxygen in the coastal waters around Taiwan from August 1973 to April 1978. Generally oxygen concentrations were controlled by temperature, and low values were observed in polluted areas, particularly Koahsiung Harbor. Primary productivity varied between 0.04 and 1.22 g carbon/meter^2/day, the highest value being observed near the estuary of the Ta-Tu river where clams and oysters are cultured.

L. P. Lin, Department of Agricultural Chemistry, NTU, reported on the production and activity of chitinase and cellulase in estuarine systems of the west coast of Taiwan. A strain of bacteria of the genus *Cellulomonas* was found to be high in cellulase activity and a *Flavobacterium* sp. was high in chitinase activity. The enzyme producing bacteria were more numerous in the sediment than in the water column and in summer than in winter. The numbers were not significantly correlated with the number of coliforms.

Marine yeasts were isolated and characterized using phase contrast and electron microscopy. Seven genera were identified and maximum numbers were 7.4 x 10 per gram of sediment, 1.3 x 10^3 per ml of seawater in two areas where shellfish are cultivated.

Many of the papers were concerned with pollution of the aquatic environment by heavy metals, pesticides, oil, and various industrial wastes. A paper by Y. Kitano, N. Kanamori, and R. Fujiyoshi of Nagoya University (Japan) was concerned with the coprecipitation of cadmium with calcium carbonate. Although the paper described laboratory experiments, cadmium is a common industrial pollutant and is related to the "*Itai-Itai*" ("ouch-ouch") disease. No thermodynamic distribution constant for the incorporation of cadmium in calcium carbonate could be found. However, marine carbonate sediments generally contain very little cadmium, and such sediments are believed to be of little significance in the removal of cadmium from seawater.

Six other papers were concerned with various aspects of heavy metal behavior and pollution effects:

Y. Kitano and M. Sakata (Nagoya University) discussed the behavior of some heavy metals when river water enters the ocean. A preliminary study of the behavior of copper and cadmium during storage of seawater samples suggested that in normal seawater copper is present chiefly as $Cu(OH)_2^0$, cadmium as $CdCl_2^0$ and $CdCl^+$. During a 40-day storage in polyethylene containers, significant fractions of the copper, but not of the cadmium, were absorbed on the container walls.

Selective leaching of sediment samples was carried out and showed that important parts of the iron, copper, and zinc were present in sediments from the Port of Nagoya as sulfides, whereas such was not the case for manganese, thus permitting manganese to be carried out to the open ocean.

One paper was concerned with the mercury contamination of sediments in the Suimon River, Gifu Prefecture, Japan. The mercury content seemed to have little relationship to the distance from the source of the pollutant, but it was related to such properties as ignition loss, grain size distribution and specific surface area. About 95% of the heavy metals were associated with the material lost on ignition. Experiments showed that humic substances took up more heavy metals than did clay minerals, in agreement with the observations of the natural river sediments.

Members of the Taiwan Water Pollution Control Agency reported on the contents of cadmium, chromium, copper, nickel, and zinc (determined by atomic absorption spectrophotometry) in the water and sediments collected from 17 stations in six rivers in western Taiwan in 1977 and 1978. Zinc was the most concentrated both in the water and the sediments and tended to increase downstream. A related report from the Pollution Control Agency was on the contents of the same heavy metals of aquatic life samples from ten western Taiwan rivers. The nickel content of the fish and shellfish from one of the rivers, the Wu-Chi, was higher than the other, but probably because of higher nickel content in the natural environment rather than because of pollution. Zinc was found to be more concentrated than the other metals in fish and shellfish, and copper was more enriched in shellfish than in fish.

One paper reported on the experimental uptake of cadmium, mercury, and zinc by the protein of carp, another on the toxicological effect of selenium on fish.

M. C. Lo and Y. C. Shen of the Taiwan Institute of Environmental Sanitation (TIES) reported on the history and distribution of pesticide residues in Taiwan water supplies. In 1960, one water supply was found to contain 15 μg/liter of gamma BHC (benzene hexachloride, lindane). Since 1970 most of the water supplies have been monitored monthly for pesticides, including alpha, beta, gamma, and delta BHC, p-p and o-p DDT, aldrin, endrin, dieldrin, heptachlor, parathion, malathion, sevin, sumichion, diazinon, phosdrin, and DDVP. The phosphorous pesticides decompose rather quickly and are never found in the rivers, even though they are widely used. In the north, concentrations of BHC in the rivers are highest in the rainy season (spring), when the material, which is no longer used in Taiwan, is leached from the soil. The maximum concentration of BHC observed in 1976 was only 10% of that observed in 1960.

A paper by Chang-Hung Chou of the Institute of Botany, Academia Sinica, reported on the effects of waters from various factories and from six rivers in Kaohsiung on four test plants, rice, lettuce, rye grass, and mung bean. The principal properties of the waters that were correlated with toxicity were electrical conductivity, the anions chloride and sulfate, ammonium, and some other cations.

The final papers of the colloquium were rather technological, dealing with specialized waste treatment methods, pollution control, and industrial waste disposal plants.

Technical field trips included the site of the partially completed sewage treatment plant in Taipei, a solid waste disposal plant in Keelung, and a nuclear power plant in Chinsen.

A GLIMPSE OF PHYSICAL OCEANOGRAPHY PROGRAMS IN JAPAN

Takashi Ichiye

INTRODUCTION

I had a chance to visit Japan from September 7 to 29, 1978, supported by NASA (National Aeronautics and Space Administration) Wallops Flight Center and the Office of Naval Research (ONR). The object of the NASA contract is to obtain information and data about the geoid over the ocean near Japan to permit use of Seasat-A laser altimetry data for determining the geostrophic velocity of the currents, particularly the Kuroshio. I also wanted to find out about the plans of Japanese oceanographers for hydrographic observations of the Kuroshio, the Oyashio, and the Tsushima currents to provide sea truth to permit the application of satellite altimetry to physical oceanography.

The objective of my ONR supported project was to make preliminary expendable bathythermograph (XBT) observations from the R/V *Hakuho Maru* of the Ocean Research Institute of University of Tokyo, along the Kuroshio frontal zone south of Tokyo.

My original plan for the Kuroshio observations was to board the ship for a week and disembark at Hachijo Island using a boat carried on the ship. However, it turned out that the ship could not come close to the island because of her tight research schedule and because overtime for her crew is strictly regulated by the Japanese Maritime Union. The problem was partially solved when some of the scientific party agreed to launch XBT's for me during the cruise. However, I spent almost half a day inspecting the ship's hydrographic instruments, including the computer system and the navigational equipment, in port at Harumi Wharf in Tokyo. I visited several institutions in Tokyo, Sendai, Shimizu, Kyoto, Kobe, and Hiratsuka and talked with most of the physical oceanographers. My last visit to Japan was in 1970 during the Ocean World conference in Tokyo sponsored by IAPSO (International Association of Physical Sciences of the Ocean). My first impression in the present visit is that both facilities and personnel in physical oceanography have changed radically in the intervening years.

TOKYO AREA

OCEAN RESEARCH INSTITUTE
UNIVERSITY OF TOKYO

The academic activities in physical oceanography (and all other disciplines in oceanography) are centered at Ocean Research Institute (ORI) of the University of Tokyo. The Institute was started in 1962, mainly by the effort of Professor Koji Hidaka, who served as the first director from 1962 to 1964. However, as many physical oceanographers admit, ORI is rather strong in marine biology but weak in physical oceanography because there is only one chair for this discipline; it is occupied by Professor Toshihiko Teramoto. He was a student of the late Professor Kozo Yoshida and originally an instrument specialist, but now he coordinates the physical oceanography program of the R/V *Hakuho Maru*. It is rather a hectic job, because the ship may be used by all oceanographers in Japan by submitting proposals. However, the ship's cruises are planned for three years in advance, making it difficult to incorporate a new program into a cruise plan decided one to four years earlier. There is a growing criticism among Japanese oceanographers of this rather inflexible cruise planning.

The Associate Professorship in Physical Oceanography is vacant, but there are two research associates, Keisuke Taira and Kensuke Takeuchi, both active in experimental work, particularly current measurements at moored current meter site B (centered at 30°N, 146.5°E). Lecturer Atsushi Takada, who has just come back from University of Oklahoma, is working on air-sea interaction. Other physical oceanographers in different laboratories at ORI are as follows:

Dr. Masahiro Endo (Research Associate in Marine Meteorology), numerical modelling of typhoon effects and of coastal upwelling and fronts; Dr. Ryuji Kimura (Associate Professor in Marine Meteorology), laboratory modeling of convection and its application to oceanography; Dr. Toshiyuki Hirano (Professor in fishery physics), drifter experiments for transport of plankton and larvae; Dr. Keiichi Hasunuma (Research Associate in fishery physics), descriptive oceanography of the Kuroshio.

GEOPHYSICAL INSTITUTE
UNIVERSITY OF TOKYO

The Institute (equivalent to a department in our university) is responsible mainly for graduate education and secondly for research in physical oceanography. The untimely death of the late Professor Yoshida seems to have left a big hole in the academic activities in physical oceanography in this Institute (and perhaps in the whole Japanese academic community). His chair is temporarily occupied by Professor Kinjiro Kajiura, whose main job is Director of the Earthquake Research Institute of the same university. However, since his primary interest is in long waves, Yoshida's graduate students, including three or four predoctoral students, are much distressed by his death. Dr. Yutaka Nagata is Associate Professor in physical oceanography and is interested in laboratory experiments on wave breaking and OTEC (Ocean Thermal Energy Conversion) modelling.

Some recent graduate students who have finished doctoral dissertations are listed together with their dissertation topics:

Jhong Hwan Yoon, numerical modelling of the circulation in the Japan Sea;
Michio Kishi, descriptive study of coastal upwelling in Sagami Bay;
Masahisa Kubota, measurements of shelf waves off the Northern Pacific coast of Japan.

HAKUHO MARU

The *Hakuho Maru* was described in the ONR *Scientific Bulletin*, Volume 3, No. 1. She is the largest (95m long) and best oceanographic research vessel in Japan, though she is a bit old (launched in 1967). Her navigation systems include satellite navigator and Loran C, though the navigation officers complain that the Loran C sometimes becomes unreliable. Her hydrographic equipment includes STD, XBT launcher, A frame, and several winches, one central computer for processing STD and navigational data, and two minicomputers for digitizing XBT and other special chemical and biological data (for example, flow meters on plankton nets). She can accommodate about 27 scientists, all with double occupancy except for the chief scientist, who has a single room. Accommodation for scientists is better than on most of the United States research vessels including the *Atlantis II* and *Knorr* of Woods Hole Oceanographic Institution (WHOI) and the *Researcher* and *Oceanographer* of the National Oceanic Atmospheric Administration (NOAA), according to my experience in participating in cruises of these vessels.

NATIONAL POLAR RESEARCH INSTITUTE

National Polar Research Institute (NPRI) is under the jurisdiction of Ministry of Education, Science and Culture, and is independent of any university but is organized similarly to a university institute with professors,

associate professors, etc. The Director is Professor Takeshi Nagata, well-known geomagneticist. The Institute has one program of physical oceanography or more specifically sea ice headed by Professor Kou Kusunoki, but the Institute also includes some marine biologists working on the Antarctic krill.

Other institutions engaged in physical oceanography in Tokyo belong to the Hydrographic Department, the Japan Meteorological Agency, and the Fisheries Agency; they seem to be even more mission-oriented than NOAA laboratories. However, the three agencies have coordinated seasonal hydrographic observations of the three main currents (Kuroshio, Oyashio, and Tsushima) around Japan since about 1948. The data thus obtained are used by their agencies for their respective purposes (the Hydrographic Department for notices to mariners, the Meteorological Agency for climate and long-range weather prediction, and the Fisheries Agency for prediction of fishing grounds and fish catches). This suggests that oceanography has been one of the major sciences with which the Japanese government is concerned for the welfare of the nation.

HYDROGRAPHIC DEPARTMENT
MARITIME SAFETY AGENCY

The Hydrographic Department belongs to the Maritime Safety Agency, equivalent to our Coast Guard. The Director is Dr. Daitaro Shoji (who was a classmate of the late Yoshida and myself at the First High School, which was almost equivalent to Eaton in England as a preparatory college for Imperial Tokyo University in pre-war Japan). The Department operates a number of research vessels, among which the *Shoyo* is the newest (built in 1972) and largest (1900 gross tons). The *Takuyo* (771 gross tons) was the ship used for launching four satellite tracking drifters in the Kuroshio by Dr. Dennis Kirwan of Texas A&M in 1977. Most of oceanographers working at the Department are mission oriented. However, Hideo Nitani (chief of Japanese Oceanographic Data Center) is interested in explaining observed meanders of the Kuroshio as Rossby waves and is working on a statistical analysis of the current and water mass distributions in the Kuroshio. Sadakiyo Hiri and Hideo Nishida are also active in measurements of the Kuroshio with current meter arrays and using the geostrophic method.

MARINE METEOROLOGY DIVISION
JAPAN METEOROLOGICAL AGENCY

The Division Director is Dr. Jotaro Masuzawa who once studied for a year with Professor Raymond Montgomery of Johns Hopkins University. The Division coordinates oceanographic activities including seasonal hydrographic measurements of the adjacent seas of Japan by four Marine Observatories (Kobe, Nagasaki, Hakodate, and Maizuru), each of which operates its own research vessel. The Division also operates two larger research vessels, *Ryofu Maru* (1600 gross tons) and *Keifu Maru* (1976 gross tons). The *Ryofu Maru* is older but is equipped with oceanographic instruments, whereas the *Keifu Maru* is oriented towards meteorological observations with weather radar. The former suffers a little from the agency policy that as many instruments as possible should be made in Japan, and the Japanese made Salinity-Temperature-Depth (STD) does not work properly although it was installed years ago. One of the physical oceanographers in the division is Dr. Hayato Iida, who worked with me in 1962-63 at Florida State University and Lamont Geological Observatory. He is now working on bottom pressure and current measurements at two stations across the Kuroshio southeast of Kyushu. Katsumi Hata continues descriptive studies of the Oyashio, particularly of warm eddies of Kuroshio origin.

METEOROLOGICAL RESEARCH INSTITUTE
JAPAN METEOROLOGICAL AGENCY

Unlike other governmental institutions and agencies in Tokyo, which usually have new, impressive buildings constructed during the late sixties or early seventies, this Institute maintains a number of old barracks inherited

from the Army Meteorological Division during World War II. However, I was told that the Institute will move to the new facility in Tsukuba, about 50 miles north of Tokyo, within year or so. The Physical Oceanography Division is headed by Dr. Toshio Nan'niti, who is interested in oceanic turbulence. As the objective of the Institute is to provide a scientific basis for the major operations of the mother agency, the research is not purely academic. Section chiefs are Dr. Ichiro Isozaki, who is now working on prediction of ocean waves after publishing a number of papers on storm surges and abnormal tides, and Shunji Konaga, who is working on descriptive oceanography of the Kuroshio. Also there are several younger scientists who have finished MS degrees in Tokyo or Kyoto University but do not have a PhD. This is common among physical oceanographers in governmental agencies and institutions in Japan. The main reason is that the civil service examination for scientific and technical personnel has become highly competitive in recent years. The examination problems are mainly concerned with basic physics and mathematics and are reputed to test mainly the memory of the applicants. Therefore applicants with a fresh memory of these subjects have the advantage. If a graduate student spends too much time in a specialized field earning his doctorate, he may be handicapped. In addition, the hiring salary is not much different for a successful applicant with MS or PhD degree.

TOKAI REGIONAL FISHERIES RESEARCH LABORATORY, TOKYO JAPAN FISHERIES AGENCY

Physical oceanography is pursued by a group in the Radioactivity Research Division. The Laboratory operates R/V *Soyo Maru* mainly for fishery studies but also for cooperative observations of the Kuroshio and the Oyashio. Physical oceanographers are headed by Dr. Hideo Sudo, who worked with me at Texas A&M in 1969 to 1971 and is now studying the deep ocean circulation southeast of Japan, particularly in connection with future oceanic disposal of nuclear waste material. Akira Tomosada is working on warm eddies of Kuroshio origin in the Oyashio region, and Yasuo Matsukawa is interested in the meanders and the cold water masses of the Kuroshio.

PHYSICO-CHEMICAL INSTITUTE

One private institution, the Physico-chemical Institute (Rikagaku-Kenkyusho), supported heavily by the Japan Science and Technology Agency, is several miles north of Tokyo and contains two groups, coastal and offshore oceanographers. The latter group is represented by Dr. Kenzo Takano, who worked on numerical modelling of oceanic circulation with meteorologists of the University of California, Los Angeles, but now is active in measurements of the currents near B-site.

AD-HOC MEETING FOR APPLICATION OF SATELLITE ALTIMETRY TO PHYSICAL OCEANOGRAPHY

The geoid of the oceanic area is important for determining sea level deviations from geoid. Most active in determining the geoid near Japan is Dr. Yasuhiro Ganeko of the Hydrographic Department. He compiled the gravity data and constructed the geoid around Japan, though Professor Yoshibumi Tomoda and Dr. Jiro Segawa are active in field measurements of gravity using ship-borne gravity meters. There was an ad-hoc meeting for me with geodesists and physical oceanographers at ORI on September 8, 1978 for discussing exchange of satellite altimetry data, geoid data, and hydrographic data in the Kuroshio region.

SENDAI AREA

Sendai is about 200 miles north of Tokyo. Tohoku University was the third oldest Imperial University in prewar Japan. Its Geophysical Institute has a Physical Oceanography Laboratory directed by Professor Yoshiaki

Toba, who is energetically working on experimental studies of wind waves. Associate Professor Takashige Sugimoto did experimental work on tide-residual currents and is now working on a rotating model study of the coastal effect on the Kuroshio. There are about a dozen graduate students, some of whom have almost finished doctoral dissertations, such as Sanshiro Kawaii and Masayuki Tokuda. It appears to me that most of the graduate students are working on experiments on wind waves with Professor Toba.

TOHOKU REGIONAL FISHERIES RESEARCH LABORATORY
FISHERIES AGENCY

Its main working area is off Sanriku (northern Pacific province) and covers the frontal zone between the Kuroshio and the Oyashio. There is a small physical oceanography program headed by Ryuya Kuroda, who is interested in warm eddies from the Kuroshio.

TOKAIDO AREA

Tokaido was the old Japanese road on the Pacific coast between Tokyo and Kyoto; the famous highway was lined with pine trees as shown in Hiroshige's woodblock prints. Now the bullet trains connect the two cities, 300 miles apart, in less than three hours at intervals comparable to the rush hour New York subway schedule. However, there is little physical oceanographic activity in this province except at Shimizu and Hiratsuka.

Shimizu is a port city well-known for exporting tea to United States since the Meiji era (1868-1911) and also for Jirocho of Shimizu, number one kyokaku gambler, labor-supplier, and protector of common people against the samurai in the feudal age. Two institutions concerned with oceanography are located side-by-side in this city.

TOKAI UNIVERSITY

The Faculty of Marine Science and Technology of Tokai University is a part of a new private university that has branches in colleges and high schools all over Japan. The Faculty of Marine Science and Technology was founded in 1962 under Dean Kanji Suda, who was one of the three pioneers, along with Professors Hidaka and Michitaka Uda, in physical oceanography in Japan. It consists of seven Departments (Ocean Engineering, Ocean Civil Engineering, Ocean Resources, Fisheries, Naval Architecture, Ocean Sciences, and Navigational Engineering). All the Departments are mainly devoted to undergraduate education with almost five thousand students. There are graduate Departments in ocean engineering and ocean resources. The faculty has two large research and training ships *Tokaidaigaku Maru* II (130 ft, 703 GT) and *Bosei Maru* (190 ft, 1103 GT), which is soon to be replaced by a new and larger ship. The faculty includes a number of older physical oceanographers such as Dr. Yoshitada Takenouti and Dr. Kozo Hishida and marine meteorologists Dr. Ichiro Imai and Dr. Hidetada Huti, all of whom are retirees from other institutions. Most active is Associate Professor Yasuhiro Sugimari, who is working on remote sensing. He did some work on the determination of wave spectra by applying laser-holography to sea surface photographs and spent two years with me at Texas A&M in 1973 to 1975.

FAR SEA FISHERIES RESEARCH LABORATORY
FISHERIES AGENCY

The Far Sea Fisheries Research Laboratory is concerned particularly with tuna fishing and Antarctic whaling, which is to be discontinued in the future. Dr. Ichiro Yamanaka and Hajimo Yamanaka (no kin) are working on descriptive oceanography of the tropical Pacific.

COASTAL OCEANOGRAPHY LABORATORY
DISASTER PREVENTION RESEARCH CENTER

In Hiratsuka, one of the expanding bedroom towns of Tokyo and Yokohama about 30 miles southwest of Yokohama, is located the Coastal Oceanography Laboratory of the Disaster Prevention Research Center. The center belongs to the Science and Technology Agency, which is the largest agency sponsoring physical oceanography in Japan. According to several physical oceanographers I met during my visit, the average annual research budget for a postdoctoral physical oceanographer at Japanese universities is about $10,000 (on the basis of ¥200 per dollar) excluding salaries and shiptime support by the Ministry of Education, Science and Culture, whereas the support for the same level of physical oceanography by the Science and Technology Agency may reach ten times that amount. It has been internally ruled at most national universities that the faculty may not receive support from other agencies, but I am told that this ruling is changing.

One of the most interesting oceanographic facilities in Japan is an offshore research tower maintained by Coastal Research Laboratory about 10 miles off Hiratsuka at a sea depth of about 30m. It is equipped with wave gages of different types, anemometers, water temperature and salinity sensors at more than 10 depths, and it houses many kinds of recorders in a room which also can accommodate a few scientists for several days. All the data can be telemetered to the Laboratory. It is impressive to watch as the wave data are processed for determining spectra and other statistics almost in real time basis with a computer in the Laboratory. The Director is Dr. Noriyuki Iwata, who is interested in coastal currents and near-shore circulation. Among the younger staff, Yoshinobu Tsuji is interested in internal wave theory and the generation of tsunamis; Yukio Fujinawa is working on wind wave generation and measurements.

KANSAI AREA

The megalopolis of Kyoto, Osaka, and Kobe is almost as populous as the Tokyo-Yokohama area and probably contains more industries than the latter. However, oceanographic activities in this area seem to be only about one-tenth of the Tokyo-Yokohama area. There is no institution or agency in Osaka directly involved in oceanography.

GEOPHYSICAL INSTITUTE
KYOTO UNIVERSITY

Kyoto University is the second oldest and prestigious former Imperial University in Japan. The Geophysical Institute, as in Tokyo University, includes a chair of physical oceanography occupied by Professor Hideaki Kunishi, who is primarily interested in nearshore circulation, particularly of the Seto Inland Sea. He has about a dozen graduate students and two or three post-doctoral students including Norihisa Imasato and Yukio Onishi, who is active in numerical modelling of estuarine and lake circulation. His students work systematically on modelling of water mass mixing (and pollutant dispersion) in the Seto Inland Sea. They are now going on to model the mixing of coastal water with the Kuroshio. I was told that some observational programs are undertaken using classical methods and current meters within the Kii Channel, which connects the Inland Sea to the open ocean.

KOBE MARINE OBSERVATORY
JAPAN METEOROLOGY AGENCY

Before World War II, this institution had a strong tendency towards scientific activities and produced many eminent oceanographers and meteorologists including Dr. Suda, Professor Uda, and Professor Hidaka, who

worked here for about 12 years between 1927 and 1940. I worked here from 1945 to 1954 and thus am an alumnus of this institution. At present, reorganization of the Japan Meteorological Agency designates this institution as one of four marine observatories primarily responsible for marine forecasting in the area south of Japan. Thus there is not much research activity except operating the *Shumpu Maru* III, which is about 360 GT and makes cruises four times a year in and near the Kuroshio between Kyushu and Tokyo in coordination with the Marine Division of the Japan Meteorological Agency.

REMARKS

This description of the scientific activities of various physical oceanographers is highly subjective and mainly based on my interviews or discussions with Japanese physical oceanographers or with persons working closely with them. Therefore there may be some omissions, though not many.

The institutes covered are restricted to the Pacific coast of Japan between Sendai and Kobe, although most of the oceanographic institutions are located in this strip. One I did not visit in Tokyo is the Tokyo University of Fisheries. I was told that the Marine Science and Technology Center in Yokosuka City is generously funded by the Science and Technology Agency and is active in applied oceanography related to naval architecture. Outside the strip from Sendai to Kobe, the Applied Mechanics Institute of Kyushu University in Fukuoka includes several physical oceanographers interested in geophysical fluid dynamics wind waves. In Hokkaido, a number of physical oceanographers are working at College of Fisheries of Hokkaido University in Hakodate and at the low Temperature Research Institute of the same university in Sapporo.

MICROBIOLOGY AND TOXINOLOGY IN JAPAN

Neal B. Groman

A recent visit to Japan has reminded me that there is a small but excellent group of Japanese scientists working in the area of toxinology, in particular those concerned with bacterial toxins. A number of these workers participated in the last two Gordon Conferences on Microbial Toxins in 1976 and 1978, and some have spent considerable time in the United States working on research.

Three investigators are at the Research Institute for Microbial Diseases at Osaka University. Dr. Tsuyoshi Uchida has been a major contributor to work on the genetics and transport of diphtheria toxin. He is currently working on methods for conjugating the active fragment of toxin to various lectins with a view to increasing the cell range and specificity of toxin action. An underlying purpose of this and work of other investigators is ultimately to couple toxic moities with conjugates that are specific for tumor cells. At the same Institute Dr. Morihiro Matsuda's work is concerned with the structure of tetanus toxin and that of Dr. Yoshifumi Takeda with the characterization of toxin produced by *Vibrio parahemolyticus*. In this he has collaborated with Dr. Kiyota Goshima from the Takeda Chemical Industries, Ltd., in their biological laboratories in Osaka to study the effect of the toxin on heart tissue in culture. A fifth investigator, also in the Osaka region, at the College of Agriculture of the University of Osaka Prefecture is Dr. Genji Sakaguchi whose work is concerned with the purification and characterization of the toxins produced by *Clostridium botulinum*. This list of investigators by no means exhausts the possibilities in this field of work but represents areas with which I am most familiar.

During the visit to Japan in October 1978 I was the guest of Dr. Yohei Ito who is the Chairman of the Department of Microbiology, Faculty of Medicine at Kyoto University. Dr. Ito is internationally recognized for his work in tumor virology and has assembled a young and vigorous group of investigators to pursue problems in this field and in tumor immunology. I also met Dr. Hisaeo Uetake at the Institute for Virus Research, Kyoto University, and he has a group working on animal viruses with particular emphasis on the surface components of tumor inducing viruses.

MOLECULAR SCIENCE AT HOKKAIDO UNIVERSITY

Mitchel Weissbluth

The origins of Hokkaido University may be traced to the Sapporo Agricultural College founded in 1876 with the able assistance of an agricultural expert from Amherst, Massachusetts, by the name of Dr. W. S. Clark who, in the relatively brief period of ten months and with no knowledge of Japanese, became the first Vice President of the first higher agricultural educational institution in Japan. A bust of Dr. Clark now stands on the campus of the Agricultural Faculty and various memorabilia of that period are on display in the Faculty Lounge. In 1918 the Sapporo Agricultural College became the Hokkaido Imperial University and in 1947–consistent with prevailing trends–the name was shortened to Hokkaido University. A period of rapid growth ensued so that at the present time the University, with the largest campus area among the Japanese universities, consists of 12 faculties, 13 graduate schools and 4 research institutes with 12,000 students divided more or less equally between undergraduates and graduates.

Sapporo, the city in which Hokkaido University is located, is in the southwestern region of the northernmost island of Hokkaido and, with a population of over a million, Sapporo is one of the nine big cities of Japan. In marked contrast to Tokyo, most of Sapporo is laid out in rectangular blocks with wide streets and boulevards. The surrounding mountains provide a picturesque back drop especially in winter when the snow-covered slopes offer numerous recreational opportunities of sufficient excellence for Sapporo to have been the site of the Winter Olympic Games in 1972. A further attraction is the deservedly famous Sapporo Brewery which either by coincidence or design opened its doors only two years after the arrival of the first students at the Sapporo Agricultural College.

I spent four days at the University under the guidance of Professor Kimio Ohno of the Department of Chemistry, Faculty of Science. In addition to Professor Ohno's Quantum Chemistry group, I visited research groups under Professor Isao Yamazaki at the Institute of Applied Electricity (IAE), Professor Katsumi Kimura (IAE), Professor Hiroaki Baba (IAE), Professor Masao Kimura, Department of Chemistry, Faculty of Science, Professor Yasutomo Ozawa, Department of Atomic Engineering, Faculty of Engineering and Professor Meiseki Katayama, Department of Atomic Science and Nuclear Engineering, Faculty of Engineering. It was somewhat puzzling to find that within the 14 research divisions of the Institute of Applied Electricity there are active groups in fields which one would normally not regard as applied electricity, for example, physiology, applied mathematics, biophysics. It was explained that there are historical reasons for the name of the Institute and although it was recognized that a new name would be more appropriate, there has been no general agreement on a new name and so the old one persists.

The general theme of Professor Ohno's research is the computation of atomic and molecular properties with emphasis on simple organic molecules and metal-organic complexes. The computations are within the class known as *ab initio* SCF CI which is an abbreviation for a non-empirical computation by the self-consistent field method with configuration interaction. To understand the nature of the problem it is necessary to refer to the Hartree-Fock (HF) equations whose solutions provide atomic or molecular wave functions. Difficulties arise because the Hartree-Fock system consists of coupled, integro-differential equations which can only be handled by a self-consistent method, that is, by iteration from an assumed, approximate solution. Various approaches have been developed; they all involve approximations to some degree but–and this is the key point–even if the Hartree-Fock equations could be solved exactly and relativistic effects taken into account properly, there is still a residual error arising from the manner in which inter-electronic interactions are treated in the Hartree-Fock formalism. More specifically, for electrons whose spins are parallel there is partial compensation from exchange

interactions but for those with opposite spin, exchange interactions are absent and the motion of such electrons remains uncorrelated. In reality, of course, all the electrons are subject to Coulomb interactions and their motion must be correlated. This so-called correlation-energy problem is a major obstacle in atomic and molecular physics and much effort, in Japan and elsewhere, has been expended toward its solution.

A common approach to the correlation-energy problem is the configuration-interaction (CI) method. In its most elementary form it expresses the wave function as a linear combination of Slater determinants of the required symmetry, each determinant corresponding to a possible electronic configuration. A variational principle is then applied to calculate the energy and the wave functions from which all other properties can be derived. However, the implementation of the method rapidly becomes prohibitive as the number of electrons increases and, despite advances in computer technology, only the simplest atoms and molecules have been computed in this fashion. The objective of configuration-interaction theorists is to devise more efficient methods.

Professor Fukashi Sasaki, a member of Ohno's group, is a young theorist active in this endeavor. He developed a powerful method in which a Hamiltonian matrix element is expressed as a sum of integrals over radial functions (F. Sasaki, Int. J. Quant. Chem *8*, 605 (1974)). Subsequently, together with M. Yoshimine of IBM, correlation energies and electron affinities for boron, carbon, nitrogen, oxygen, fluorine and neon were calculated (F. Sasaki and M. Yoshimine, Phys. Rer. *49*, 17 (1974); Phys. Rer. *49*, 25 (1974)). The calculated correlation energies ranged from 95 to 97% of the experimental values and the calculated term energies of carbon were within 2% of their spectroscopic values. More recently, Sasaki together with T. Noro and H. Tatewaki concluded a theoretical study (as yet unpublished) of the scattering of electrons by neon atoms for incident energies from 16 to 19 eV. The method employed is an adaptation of the R-matrix theory of nuclear reactions developed by E. Wigner in 1946. In this theory one distinguishes between an external interaction region where the two interacting particles are separated by a distance greater than the sum of their radii, and an internal region, where the separation is smaller than the sum of the radii. In the external region the interaction is described by a potential but in the internal region the particles interact strongly and lose their individual identity. The two regions are calculated separately and the wave functions are subsequently matched at the boundary. In this fashion Sasaki and coworkers calculated the elastic and inelastic cross sections as well as the positions and widths of the neon resonances below the ionization potential.

An ab initio SCF CI calculation of the π-electron system of the pyrrole molecule was recently concluded (I. Tanaka, T. Nomura, T. Noro, H. Tatewaki, T. Takada, H. Kashiwagi, F. Sasaki and K. Ohno, J. Chem. Phys. *67*, 5738 (1977)). It yielded assignments of the four singlet states lying between 5.9 and 7.4 eV and the triplet state at 4.35 eV. The calculated ionization potentials were in quite good agreement with experimental values. Other projects by this group include Rydberg states of calcium, complexes of cobalt and copper with porphine, photo-dissociation of methane, symmetry orbital transformations and spin-spin coupling.

Professor Isao Yamazaki is Chairman of the Biophysics Section of the Institute of Applied Electricity. His research mainly involves enzymatic reactions. In 1969 he found a set of appropriate conditions which promote an oscillatory reaction in the peroxidase system (S. Nakamura, K. Yokota and I. Yamazaki, Nature *222*, 794 (1969)). The specific enzyme is lactoperoxidase which catalyzes the oxidation of reduced pyridine nucleotide with the consumption of oxygen and the conversion of lactoperoxidase to compound III—so called, because of its uncertain characterization but thought to be a complex of ferriperoxidase and O_2^-. The concentration of compound III—detected by its absorbance at 433 nm—and the concentration of oxygen both oscillate with a period of about two minutes. In a later publication (I. Yamazaki and K. Yokota, Mol. and Cel. Biochem. *2*, 39 (1973)) the five known oxidation states of peroxidase and the possible mechanism for the oscillatory behavior are discussed. Temporal oscillations and spatial periodicities in chemical systems—the latter pioneered in the Soviet Union—have aroused considerable interest and speculations abound as to their mechanisms and possible biological significance. Recently, the acid-base behavior of monomeric hemoproteins—a category that includes peroxidase, myoglobin and subunits of hemoglobin—was reviewed (I. Yamazaki, T. Araiso, Y. Hayashi, H. Yamada and R. Makino, Adv. Biophysics, *11*, 249 (1978)). It is noted that the pH dependence of reactions of

peroxidase with ligands differs markedly from those of myoglobin. Yamazaki et al. advance the hypothesis that these differences have their origin in the strength of the interaction of a distal group with the sixth ligand. In myoglobin this interaction is weak whereas in peroxidase it is very strong, presumably through the influence of the electron density on the iron. It should be noted, however, that the lack of structural information on peroxidase prevents the hypothesis from being fully tested.

It is perhaps an obvious truism that the activities of scientists generally vary in both time and space. Thus it was that my conversation with Professor Yamazaki revealed a prior connection with Professor Yuzuru Ishimura who is now in the Department of Biochemistry, School of Medicine, Keio University, Tokyo, and whom I had visited on a previous occasion. Several years ago they were interested in a class of enzymes known as oxygenases whose function it is to catalyze the incorporation of molecular oxygen into various substrates. There are numerous enzymes of this type and some of them, like cytochrome P-450, play an important role in relation to the carcinogenic properties of polycyclic hydrocarbons. In a paper published in 1970 (Y. Ishimura, M. Nozaki, O. Hayaishi, T. Nakamura, M. Tamura and I. Yamazaki, J. Biol. Chem. *245*, 3593 (1970)) an investigation was carried out on the oxygenase L-tryptophan 2, 3-dioxygenase which is an iron porphyrin protein. They showed that first L-tryptophan binds to the ferrous enzyme as a result of which there occurs an increase in the reactivity of the heme toward oxygen. The complex tryptophan-enzyme-oxygen then acts as an intermediate to promote the interaction between the two substrates–tryptophan and oxygen. It was further shown that the binding of tryptophan to the enzyme resulted in an increased reactivity of the heme towards ligands such as cyanide and carbon monoxide–yet another example of the allosteric effect whose fundamental mechanism remains quite obscure. More recently, the emphasis in Ishimura's group at Keio University has shifted toward the study of cytochrome P-450, while Yamazaki at Hokkaido University is paying increased attention to free radicals that are formed in the course of oxidation-reduction reactions catalyzed by enzymes (I. Yamazaki, Free Radicals in Biol. *3*, 183 (1977)).

Professor Katsumi Kimura heads a research group in spectroscopy of organic compounds at the Institute of Applied Electricity. They cover a wide range of investigations which include the following:

(a) photoelectron spectroscopy of free molecules
(b) photo-induced radical-ion formation
(c) vacuum ultraviolet absorption studies of molecular Rydberg states
(d) flash spectroscopic studies of photochemical intermediates
(e) ionic photodissociation of weak ground-state electron-donor-acceptor complexes in solution
(f) triplet state ionic photodissociation of weak charge transfer complexes
(g) biphotonic ionic dissociation of weak charge transfer complexes in glassy solutions
(h) triplet-triplet absorption spectra
(i) sum rule considerations of molecular photoelectron spectra.

Professor Hiroaki Baba of the Institute of Applied Electricity has been concentrating on the fluorescence of organic molecules. Fluorescence in molecules is most often observed from the first excited singlet state (S_1) even when the excitation energy is sufficient to raise the molecule to higher excited singlet states; the reason for this is that the lifetime for internal conversion (degradation of the energy through vibrational transitions) is usually much shorter than for fluorescence. But there are exceptions. In a study of pyrene vapor H. Baba, A. Nakajima, M. Aoi and K. Chihara (J. Chem. Phys. *55*, 2433 (1971)) observed fluorescence from the second excited singlet state (S_2) and studied the phenomenon with particular attention to changes in the emission characteristics with excitation energy. The fluorescence from S_1 had a constant quantum yield regardless of excitation energy, but the quantum yield for the fluorescence from S_2 increased rapidly with excitation into successively higher singlet states. The anomalous behavior is attributed to a higher density of vibrational states in S_2 than in S_1–a feature which could result in a reverse internal conversion, that is, from an excited vibrational state of S_1 to an excited vibrational state of S_2. In a later publication (K. Chihara and H. Baba, Bil. Chem. Soc. Japan *48*, 3093 (1975)) the effects of foreign gases on the fluorescence from the first (S_1) and second (S_2) excited singlet states of

pyrene were investigated. Oxygen quenches both S_1 and S_2 fluorescence; cyclohexane produces a blue shift and an increase in the quantum yield of S_1 fluorescence and an increase in the lifetime of S_1 while S_2 fluorescence exhibits only a slight blue shift and a marked decrease in quantum yield and lifetime.

I was impressed with the instrumentation in Baba's laboratories. Not only are they well-equipped with commercial instrumentation of recent vintage but also with instrumentation designed and constructed within their own facilities. Baba mentioned that one of the advantages of being in the Institute of Applied Electricity, rather than in the Faculty of Science, is that he had better technical support, e.g., electronics, machine shop, mechanical design, etc. An apparatus for measuring fluorescence lifetimes by means of time-to-amplitude conversion was developed in Baba's group as well as a photon-counting spectrophotometer specially designed for measuring weak emissions. With the latter instrument they were the first to observe fluorescence from pyridine vapor in the lowest excited singlet state reached by a n-π^* transition (J. Chem. Phys. *66*, 5826 (1977)).

Research in infrared spectroscopy is conducted in the laboratory under the direction of Professor Masao Kimura. Here again the research is of a wide-ranging nature. A few recent topics and their associated publications are the following:

(a) infrared band shape of the C-I stretching vibration of methyl iodide in solutions (K. Fujiwara, K. Fukushi, S. Ikawa and M. Kimura, Bul. Chem. Soc. Japan *48*, 3464 (1975)).
(b) Raman band shape of sulfuric acid and proton transfer (S. Ikawa and M. Kimura, Bul. Chem. Soc. Japan *49*, 2051 (1976))
(c) far infrared absorption intensity of hydrogen chloride dissolved in carbon tetrachloride (Y. Ohkubo, S. Ikawa and M. Kimura, Chem. Phys. Let. *43*, 138 (1976))
(d) ν_1 Raman linewidth of SO_4^{2-} in acidic solutions (S. Ikawa, M. Yamada and M. Kimura, J. Raman Spect. *6*, 89 (1977)
(e) far infrared absorption intensities and the dipole moments of some molecules in solutions (K. Sato, Y. Ohkubo, T. Moritsu, S. Ikawa and M. Kimura, Bul. Chem. Soc. Japan *51*, 2493 (1978)).

I had but a short time for a brief visit with Professor Yasutomo Ozawa and Professor Meiseki Katayama both of whom are in the Faculty of Engineering. They have a 45MeV electron linear accelerator of Japanese design which enables them to do neutron diffraction, fast neutron spectroscopy by time of flight, picosecond pulse radiolysis, activation analysis and other related types of experiments. Other interests of the group include electron spin resonance studies of γ-irradiated solid organics (M. Katayama, H. Itoh, R. Shimada and T. Sumiyoshi, Chem. Let. 1259 (1973)), radiation-induced ionic polymerization (M. Katayama and S. Ushimaru, Chem. Let. 769 (1974)). They have also developed a rapid-scan infrared spectrophotometer with scan rates of 125cm^{-1}/m sec at 3000 cm^{-1} and 12 cm^{-1}/m sec at 500 cm^{-1} and a repetition interval of 20 m sec. With this instrumentation they measured the emission spectrum in the explosion of CO-O_2 mmixtures.

Professor Ozawa is also Director of the Energy Conversion Research Institute which pursues basic and applied research on energy conversion processes through electromagnetic interactions. Projects that were mentioned include:

(a) electrical discharge control of plasma in MHD generators
(b) development of ferromagnetic electrode type MHD generators
(c) real time holographic intereferometry for plasma diagnostics
(d) carrier chain concepts in energy generation and energy conversion.

THE 4TH ACOUSTIC EMISSION SYMPOSIUM

Kanji Ono

This symposium was the fourth in a series of conferences devoted to acoustic emission and held every other year in Tokyo. The first was held in 1972 with several invited speakers from the United States and over a dozen contributions by Japanese workers. This fourth symposium was held 18-20 September 1978 and attended by nearly 100 participants (mostly from Japan but including representation from the United States, United Kingdom, West Germany, and Union of Soviet Socialist Republics). The Symposium papers were published in the proceedings as "The 4th Acoustic Emission Symposium" by the secretariat of the Symposium, International Technical Exchange Center (TEC), Nagatacho 2-13-80, Chiyoda-ku, Tokyo. The proceeding was distributed to the participants at the meeting and is available from ITEC.

SESSION 1–INSTRUMENTATION

The meeting was opened by Professor Onoe of University of Tokyo, who has been the leader of Japanese Acoustic Emission (AE) research and development and organized these symposia as well as many other AE related activities. In the session on Instrumentation, W. D. Jolly presented details of an AE system intended to perform multiple parameter analysis of AE signals with source location (or discrimination) capabilities. T. Hamada described a microcomputer based AE pulse simulator. It produces random amplitude, random interval pulse output. Their distributions are programmable. K. Yamaguchi presented results of an extensive simulation study of a multichannel AE detection system. They analyzed the accuracy of source location and the validity of various AE parameters. As effective parameters representative of propagation distance, the total energy and energy moment of a pulse appear to be most suited. Limits of source location capabilities that take into account the characteristics of received signals were studied by the simulation experiments.

T. Kishi presented results of an AE test on a rocket motor case, which was made of 18 Ni maraging steel and was pressurized till burst fracture (at 143 atm). At 100 atm, the positions of impending failure were located. Amplitude distribution data was effective in this regard, but frequency spectrum was essentially unchanged before failure. Final failure occurred apparently at two locations. A movie of the test was also shown.

SESSION 2–PLASTIC DEFORMATION

H. C. Kim discussed effects of grain size on AE energy release (corrected mean square values) from 3N pure aluminum. He integrated the mean square voltages and compared these values at different strain levels. These can be correlated to either d^{-1} or $d^{-1/2}$ (the latter is the usual Petch relation). He also indicated that the integrated AE energy is proportional to the square of the long range stress in the specimen. In both of these accounts, it is hard to reconcile with the absence of AE in highly cold-worked materials, in which the long range stress is quite high. No logical explanation appears feasible for Kim's idea of correlating the integrated mean square voltages to the internal stress levels. K. Kuribayashi studied AE due to deformation twin in mono- and poly-crystalline zinc. In a single crystal zinc, dislocation glide was found to produce the continuous type AE signals up to a few % strain, after which burst AE signals from twins start to be superimposed. Polycrystalline zinc produced mostly burst emission due to twinning. Strain rate dependence and amplitude distribution of burst AE from twins were entirely different from those of dislocation glide.

J. Masuda reported AE behavior of a precipitation hardening alloy of Cu-(4-8%)Ni-(0.9-1.5%) Si (Corson alloy). Peak AE level was observed to increase with aging time, while, at the same time, the strength levels increased about twice. Next, Y. Mori discussed Kaiser effect in metals and alloys. He defined Kaiser effect ratio (KR) as the stress where AE starts upon reloading to the prior flow stress. Only in α-Fe, mild steel and Al-3% Mg, Kaiser effect was valid; i.e., KR = 1. For same type of alloys, KR tends to decrease with diminishing stacking fault energy. He also studied effects of increasing test temperature and strain rate, both of which reduced KR. Tempering effect and interrelation with unloading AE were evaluated. This aspect should be an interesting subject for further investigation in conjunction with dislocation substructures.

K. Yoshida reported AE from low carbon steel and 304 stainless steel sheets, tested under plane stress condition via a bulge test. Burst emission was dominant during the tests. (This is similar to the findings of M. Hamstad of Lawrence Livermore Laboratory, Livermore, California, who observed mostly burst emission in biaxial tensile tests of 7075-T6 aluminum alloy.) In the last talk of the session, M. Tokiwai described AE behavior of nuclear reactor materials before and after neutron irradiation. The fluence level was 4×10^{19} n/cm^2 for zirconium and A542B steel and 0.6 and 4×10^{19} n/cm^2 for A533B steel. Twinning in Zr was suppressed by irradiation and AE decreased accordingly. Recovery of AE behavior was still incomplete even after annealing the irradiated Zr at 1023 K. Burst emission in the irradiated Zr was due to dislocation channeling. In lightly irradiated A533B samples, AE level increased slightly. However, further irradiation suppressed most of the continuous emission and increased burst emission. Radiation embrittlement was obvious in this case. Less changes were found in A542 steel.

SESSION 3—FATIGUE

H. Kitagawa presented AE due to fatigue crack growth in WT-60 steel and 5052-H24 aluminum alloy. The steel behaved similarly to other steels studied previously. The Al alloy had one count per cycle above the crack growth rate of 2 to 3×10^{-4} mm/cycle. Amplitude distribution could not be fitted to a power law type. K. Ishihara described AE test of a large steel weld, performed on a 3000 ton fatigue testing machine. Weld of 50 mm (2″) thickness, 500 mm (20″) width contained six intentional slag inclusions. It failed after 18,740 cycles. Potential failure sites were identified at 7% of fatigue life by using a source location system. AE was generated throughout a loading cycle, as previously noted by Hutton et al (Battelle Northwest Laboratory, Richland, Washington). Amplitude distribution was again non-power law type.

Y. Sakakibara reported AE behavior during fatigue crack growth of 304 stainless steel at room temperature to 873 K. AE increased with temperature, as previously reported by Nakasa. At 873 K, most of AE was during load increase from the compressive load maximum. These were attributed to oxides in a crack. T. Nagata showed the results of AE tests during cyclic bend tests of 300 mm (12″) diameter 304 stainless steel elbow (6 mm (1/4″) thick, about 3.6 m (140″) total length). The elbow was filled with liquid sodium at 873 K. This is a model assembly for a fast breeder reactor. Wave propagation on the elbow was analyzed. A source location system was used to identify valid AE from various zones. Total energy summation was shown to indicate fatigue damage (or the degree of fatigue crack propagation).

SESSION 4—AMPLITUDE DISTRIBUTION

The first session on the second day was devoted to amplitude distribution analysis. H. Nakasa described basic study concerning power-law type peak amplitude distribution. He was able to deduce several other amplitude ratios and the sums of these above a certain threshold level. Applications to various AE tests using these parameters were also described. The sum of event energy was shown to be an effective parameter for the monitoring of pressure vessels and pipings. K. Wolitz next described AE characteristics of a vessel of glass fiber reinforced plastics under hydrostatic (internal) pressure. AE count amplitude distribution was determined and found to follow a power law. For resin cracking, the slope was 1.8, while fiber cracking had the slope of 0.5.

I presented the next talk on the amplitude distribution characteristics of burst emission in high strength low alloy steels. This resulted from a cooperative study between University of California, Los Angeles (UCLA) and Nippon Kokan Kabushiki Kaisha. It was initiated during my visit to NKK Technical Research Center during May 1976. After reviewing our previous studies, the number of burst emissions was correlated to the number of MnS inclusions and other parameters. The amplitude distribution analysis of peak amplitude was described by a Weibull distribution and related to size distribution characteristics. Also discussed were three theoretical relations between AE peak voltage and stored strain energy, incremental crack area, and stress-inclusion length product. The last is most likely to be the correct interpretation. Transducer response was next discussed using a convolution integral.

The last paper of the morning session was given by W. D. Jolly, who described experience in monitoring AE from thermally stressed 150 mm (6″) thick steel plates with flaws. Differences were noted between self-propagating and self-damping cracks. For the latter type, pressure vessel requalification by AE monitoring is potentially misleading and is dangerous.

SESSION 5–FIELD APPLICATIONS

A. Pollock described several examples of AE applications to hydrocrackers, hydrotreaters, catalytic reformers and other pressure vessels during their operation. The vessel operating pressure was varied to the maximum of 105% of the working pressure at temperature up to 538°C. Most of the indications were of Grade B per ASME standard proposed, and some confirmations with ultrasonics were obtained.

M. Takahashi reported AE measurements on cracks in a linepipe. A correlation between crack length and AE energy rate was used as the criterion for AE monitoring.

T. Fuji reported results of a large scale AE test program, called the TAB project, which was started in 1974 and run by the Technical Approval Bureau of Industrial Research Institute. The main purpose of the project was to establish a consensus regarding AE test procedures among owners, fabricators and inspectors. A number of AE workers from universities and industries have participated in the project. The initial report of the results on nearly 20 pressure vessel tests was given by M. Onoe in the 3rd AE Symposium in 1976. The TAB project itself acquired a 40 channel AE location system made by Nippon Steel Corporation. However, a number of research teams also utilized their own AE systems during most of their pressurization tests, one of which was also used for a workshop on a multichannel AE system during 1976. Most of the vessels tested were subjected to a single hydrostatic test, while a limited number of them were tested to failure from artificial flaws. In the present report, repeated hydrotests were conducted on a model pressure vessel 4.8 m (16′) long and 1.8 m (6′) diameter. The wall thickness was 2.5 cm (1″) and the material was 60 kg/mm² (85 ksi) class high strength steel. On the vessel surface, many attachments were fillet welded. Some artificial weld defects were introduced in the fillet welds as well as in the vessel itself. These included blow holes, cracks, slag inclusions and incomplete penetration. AE data was collected during repeated pressurization and identified the locations of various flaws. Furthermore, AE wave forms indicated the difference between the AE source on the pressure boundary and those on the outside attachments.

K. Wolitz reported AE characteristics for critical faults in stainless steel welds, subjected to compact tension fracture toughness tests. Amplitude distribution and frequency spectrum of AE signals during plastic deformation before crack initiation were shown to be different from those during crack propagation.

The next scheduled paper by Ohtsuka et al. was cancelled and Y. Obata of Nihon University presented one entitled, "Acoustic Emission Test on a 1 m Diameter Pressure Vessel with a 60% Artificial Defect," coauthored by P. G. Bentley (U.K. Atomic Energy Authority, Risley, England). Copies of this paper were distributed at the Symposium. The test vessel was made of 25 mm thick 0.36%C steel. It had a saw cut and was pressurized 8

times, failing at 1480 psi. AE due to plastic deformation was located at the slit, but no AE that may be attributable to ductile tearing was detected. No indication of incipient failure was obtained.

T. Watanabe reported on the attempt to evaluate AE indications as to their "harmfulness." It was based on the concentration and rate of AE signals from a given zone of AE emitters, which were classified according to their potential damage to the main structure. In the proposed ASME code, this is done by an operator, while the effort at Nippon Steel Corporation is to delegate this function to microcomputers.

SESSION 6–STRESS CORROSION CRACKING (SCC)

Y. Monden described SCC in mild steel due to exposure to a nitrate solution. It was due to active path corrosion. Using two transducers and a delayed gate, he was able to separate longitudinal and shear components, the latter being more dominant. Shear waves showed a form of wave packets. SCC in a low chrome steel in HCl was hydrogen embrittlement. In this case, observed AE was primarily burst type and propagated by longitudinal wave velocity. During the incubation period of hydrogen embrittlement, AE was similar to that due to active path corrosion. H. Kusanagi examined AE bahavior of sensitized 304 stainless steel exposed to high pressure, high temperature (500 K) water. Biaxial stress state was maintained. SCC induced AE can be divided into three consecutive stages, the last of which is due to the propagation of intergranular cracks. With a higher hoop stress, the last stage became non-existent and leakage related AE (continuous type) started immediately. I. Komura concluded the session by presenting an AE study of SCC in stainless steel piping. For this work, he evaluated the wave transmission characteristic of waveguides, by changing the contact method to a pipe. TIG (Tungsten Inert Gas) weld was found to be satisfactory, while screw or plate type produced large waveform distortions. No sensitivity loss was observed for the TIG weld attachment. The SCC study is a preliminary one for the currently progressing exposure tests. Welds on a 4" stainless steel pipe were subjected to cyclic loading with high temperature water (70 kg/cm^2, heated at 563 Kelvin) via internal pressurization. Maximum stress was at 50% above the yield stress (i.e., 1.5 O_y) and a loading cycle lasted 90 minutes. Source locations in this test did not necessarily correspond to weld lines. Accumulated AE event counts, however, increased toward the end of the test (when leakage was observed), and AE increased even during a holding period.

SESSION 7–NONMETALLIC MATERIALS

K. Fujisawa described AE behavior of silica firebricks. Silica crystallizes in many crystalline forms and phase transformation occurs at several different temperatures. Cylindrical samples were used with high alumina waveguides. AE activities were high during the α-β transformation of crystobalite but decreased after repeated thermal cycling. In large samples (90 mm diameter), the α-β transformation of tridymite also produced significant AE activities. AE due to cracking could be recognized by the high amplitude. S. Yoshikawa discussed Kaiser effect in rocks, or the lack of it. In rocks (andesites), the conventional measure of Kaiser effect is usually ambiguous. He showed that a repeated reloading can indicate the previously applied load, by substracting the AE counts during the second reloading from those of the first. Various combination of rock conditions were examined and the new method was found to be reliable. The reason for the observed behavior appears to be the lack of microcracking during the second loading. M. Ogura presented AE due to dislocation movement in optoelectronic devices; namely, GaP light emitting diodes (LED's). AE started to increase abruptly as the light output started to decrease irregularly after the initial logarithmic decay with time. Etch pits of dislocations increased as irregular degradation initiated. This discovery can be applied to monitor semiconductor devices for their reliability, failure analysis and fabrication processes and to studies of dislocations.

A paper by Rinaldi et al was cancelled. After a break, I presented a review of recent advances in basic AE research. Developments on signal detection systems and quantitative measurements of AE signals via capacitance

transducers were discussed based on the NBS (U.S. National Bureau of Standards)* and Harwell (U.K. Atomic Energy Research Establishment) studies (Hsu et al., Mat. Eval., 1977; Hadley and Scruby, Harwell Reports** 1977, 1978). Signal analysis methods from theoretical aspects were considered, taking the elastodynamical and dislocation dynamics approaches. Work of Malen and Bolin (Phy. Stat. Sol., 1974) was reevaluated in detail and compared with other intuitive models of AE signal generation. While I was planning to discuss our recent works on deformation and fracture, these were not presented except for brief comments due to the lack of time. Additionally, short statements were made on general trends of applications of AE methods to various fields within materials science and engineering.

SESSION 8–FRACTURE

N. Ringshall presented works of frequency spectrum analysis of AE due to deformation and brittle fracture of steels. Spectrum cannot be used to differentiate plastic deformation from cleavage crack jumps, but some characteristic noise may be recognized. H. Takahashi described AE due to pop-in cracking in 4340 steel. Cumulative AE counts against the value of J integral curves had a sharp break upon the initiation of crack propagation. Next, K. Sano reported AE characteristics of ductile crack growth in HSLA steels. He analyzed AE from three HSLA (High Strength Low Alloy) steels in the transition temperature range ($-160^{\circ}C$ to $-40^{\circ}C$). Parameters derived from event counts and event amplitude as proposed by Nakasa were used to identify ductile crack initiation and growth. The mean energy of an AE event was found to be the optimum parameter. In the ductile fracture region, it was found to be difficult to distinguish crack growth from plastic deformation. K. Okajima presented the last paper of the Symposium concerning AE due to fracture in four carbon steels ($C = 0.11$ to 0.36%) and a 2-1/4 Cr-1 Mo steel. COD (Crack Opening Displacement) and J integral tests were also performed. The number of AE counts increased linearly with J below the transition region, but depended on $J^{1/2}$ in the upper shelf region. In the former range, J_{Ic} (critical value of J integral above which a crack becomes unstable) values obtained from AE coincided with those using stretch zone width. At higher temperatures, J_{Ic} values due to AE were lower than those from stretch zone width measurements.

PANEL DISCUSSION

The last two hours were devoted to panel discussion on "Present and Future Aspects of Acoustic Emission." I acted as the moderator and nine other participants (D. Jolly, H. Nakasa, A. Pollock, M. Takahashi, H. Kitagawa, K. Wolitz, N. Ringshall, T. Watanabe and H. Kim) presented their views, followed by floor discussions. The discussions were concluded by my summarizing remarks, which follow:

"Generally, AE studies may be classified into research and development. I will try to summarize the views of the panelists and the Symposium speakers on the two aspects. On the research side, needs for establishing quantitative sensor calibration is of primary importance. This will enable the quantification of AE measurements by various workers, allowing systematic comparison of AE data and aiding in the set-up of multichannel systems that must always deal with differences in the sensor sensitivities. Equally important are the studies correlating dislocation mechanisms and microscopic fracture processes to AE signals. Here, microstructural evaluation and other tools of materials research should be included to clarify the basic processes that are generally understood inadequately. It is also noted with unmistakably parochial interests that AE is emerging as a materials research technique. This observation is supported by the blossoming of numerous novel applications of AE: e.g., the detection of spalling of oxides in metal oxidation and the monitoring of firebricks for steelmaking.

On the development side, empirical approaches still appear to be dominant in the foreseeable future; i.e., AE location and other AE signal characterization are to be compared with other material evaluation methods and

*See Breckenridge et al., J. Acoust. Soc. Am. *57* (1975) 626.
**See also Reports R-8913, R-8914 and R-8915.

fracture mechanics analyses, leading to relative measures of integrity assessments. Theoretical methods of predicting AE behavior of industrial structures will probably be unavailable for sometime to come. Thus, it will be important to accumulate practical experience and to establish working criteria for interpreting AE characteristics in terms of the type and significance of various flaws.

The most impressive aspect of recent efforts on AE described during the Symposium is the widespread use of sophisticated instrumentation in acquiring valid AE signals from the zone of interest and simultaneously characterizing their amplitude distribution and other features. This represents a significant achievement. While more studies are called for to advance the state-of-the-art still further, future prospects for acoustic emission appear quite bright in the fields of materials research and nondestructive evaluation of materials and structures."

POST-SYMPOSIUM VISIT

Most of the universities and research laboratories I visited during this trip have been described previously. However, a new laboratory called "Nuclear Power Engineering Test Center (NPETC)" is worth mentioning here. As the name vaguely implies, this $35 million complex is to demonstrate the safety and reliability of nuclear reactor components and systems. Specifically, a model nuclear reactor (without nuclear fuels) is to be built just for tests, which include a demonstration of the practical use of AE systems under simulated reactor operating conditions. Already operating are 15 stainless steel piping test facilities, which subject 4" diameter pipe with 6 to 8 welds to cyclic loading with internal water pressure (about 300 atm) kept at 562 K. The loading levels range from 1.1 σ_y to 1.5 σ_y and each cycle lasts 30 to 90 minutes. Four more test stands are being readied for long term fatigue testing (up to a year) of 4" diameter pipes and for cyclic testing of 12" diameter pipes. A rapid tension test facility for 12" pipe is also being installed presently. During my visit (September 15), arranged through the courtesy of Dr. Ohno of Central Research Institute of Electrical Power Industry (CRIEPI) and accompanied by Mr. Nakasa, five cyclic tests were in progress and were monitored by AE systems from four oganizations. These include CRIEPI, Hitachi, Toshiba and Ishikawajima-Harima Heavy Industries (IHI). Toshiba and IHI utilize U.S.-made multichannel systems, while CRIEPI and Hitachi use Japanese-made AE systems. Because of high water flow rates, the background noise levels were quite high on a few of the test stands. However, some of the tests were nearing the failure stage and significant AE signals were being observed. Of interest was a remote data analysis scheme employed for the CRIEPI system. AE data were accumulated over one day and then sent to the University of Tokyo via commercial telephone line. These were to be analyzed by Professor Onoe's group. In the future, they intend to operate a multichannel AE system unattended over a long period.

The Center is located in the Isogo section of the city of Yokohama among some of large factories along the shore. The nearest train station (about 20 minutes walk) is Shinsugita on the Keihin-Tohoku line of JNR. The Center is operated by Toshiba personnel under contract to Ministry of International Trade and Industry.

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CYBERNETICS AND PATTERN RECOGNITION IN JAPAN, 1978

Thomas B. Sheridan

The author has recently visited Japan to attend two scientific meetings and to make several collateral visits to individuals and laboratories in Japan. The meetings were the *International Conference on Cybernetics and Society* (Tokyo, 3-7 November 1978) and the *International Conference on Pattern Recognition* (Kyoto, 7-9 November 1978).

Judging from these two events, when the Japanese host a scientific meeting they do a splendid job, with lots of directions, free transportation to and from hotels and smiling students always at the ready to accommodate a confused westerner with an outlandish question or request. These two meetings, sponsored by the Institute of Electrical and Electronics Engineers (primarily an American society but the Japanese sections are very active) were held back-to-back to make it easy on western attendees to attend both meetings and to make joint charter arrangements. The meetings were in English. Attendance by the Soviets, and Chinese, though some speakers were listed, was nil; they simply didn't show.

The writer participated in sessions on man-computer interaction, speech production and recognition, large-scale system and policy modeling, and "fuzzy sets." My impression is that while Japanese engineers do not seem to be producing so many new man-computer models, they are very active in implementing displays and computer-based aids which are marketable, such as packaged speech production and recognition devices. However the engineers are going in for large-scale system and policy models, and the interest in decision theory, multi-attribute utility theory, interpretive structural modeling and the like seemed quite fashionable. They are keenly aware of their own pollution problems and resource constraints. They also seem to feel such meta-analyses will help expand their production and market capabilities. I found the arguments about "fuzzy logic" were essentially between factions of westerners, with the Japanese silently but keenly watching to see who is winning. (This biased observer admits that, in a purely definitional sense, fuzzy functions handle degree-of-association relations which probability theory formally is not meant to handle. But, let's face it, many of us for years have been using the mathematics of probability to describe such relations–and it seems to work empirically, though we gloss over the definitional formalisms.)

INDUSTRIAL ROBOTS

Based upon two industrial visits and one academic visit I am certainly impressed with the agressiveness of the Japanese drive to robotize industry.

I met with Professor Yukio Hasegawa, who serves as a kind of principal academic coordinator/liaison for the Japan Industrial Robot Association (JIRA). Unlike the robotics community in the United States, which is loosely organized with various government agencies and professional societies competing for the limelight, JIRA seems to have things well in line, with many active committees and standards for robots already being accepted by industry. The 1976 draft standards are still there and being used in 1978. A new 1979 (!) MIRA report lists 127 different robot applications in industry in terms of these standards. Another MIRA document with a 1979 date claims 120 Japanese robot manufacturers, three times as many as in the United States and Europe combined. This document claims that there are 30,000 robots in operation in Japan, compared to 3,000 in the United States and Europe, and that Japan's fraction of "intelligence robots" (namely robots with computer

smarts based on their own environmental sensors and in addition to simple playback servoing) will reach 5-15% by 1985.

Visits to Kawasaki (who make Unimate robots under license to Unimation in Connecticut) and Hitachi confirmed the aggressive pace of robot manufacture and application. Kawasaki has an elaborate set-up to do continuous welds on the tubing frame joints of their motor bikes. Hitachi has robots running around inside their reactor containments inspecting and doing simple manipulations.

Hasegawa admitted to potential social impacts of robots: for the present robot-replaced workers can be absorbed in an expanding industry; should Japanese workers ever have to be laid off, there would result a traumatic loss-of-face for the company. He also related his recent experience of having encouraged Japanese manufacturers to develop robots for stamping press operations based in part on the U.S. Occupational Safety and Health Administration claim to be insisting that workers would hereafter be prohibited from putting their hands in the business areas of their presses. But to his dismay he found that American bureaucracy doesn't always follow up and enforce what it asserts and certain Japanese developers found their potential markets still had not materialized.

COMPUTER-BASED CONTROL ROOM CONSOLES

The Japanese are known for their high-quality color TV as well as their clever miniaturized pocket calculators. The know-how that produced these is also moving smartly into the development of computer-based consoles for nuclear reactors, oil refineries and chemical plants. Such plants at present have large control rooms with hundreds of dedicated panel meters and recorders, knobs and switches in neat lines with labels which are hard to identify until the operator is a few inches away. Consequently the operator must do lots of walking, and many jobs require one man to read a display at one end of the room and shout to another man adjusting a knob at the other end.

The computer-based console replaces all this, as my visit to Hitachi Energy Laboratory, a campus style set-up in the foothills of Hitachi city north of Tokyo, made evident in a new console for nuclear reactors. It is designed to be operated by one person, seated in front of two to three color CRT's and a mixture of general purpose (e.g., alphanumeric keyset) and special purpose control switches. Rather than require the operator to go to a specific location to get specific information and have to put it all together in his head, the computer-based console puts it together for him. One CRT may be used continuously to provide a status diagram of the entire plant, with different colors to represent different functions, and components changing to a special color (e.g., red) reserved to signal trouble, or possibly flashing.

The Hitachi system displayed 10 to 20 variables in a line or in a circle, and when one was seen to deviate from the "normal" pattern it was easily recognizable. If it deviated far enough both visible and audible alarms come on. The computer then compared the present readings from various plant variables with those from a real-time computer model and decides what other variables are best for the operator to observe. These variables are then displayed in bar chart or alphanumeric form, though the operator can choose to ignore these and call up any other information. The system is also capable of displaying trends of various variables on a side by side format which changes color as abnormality develops, and/or of displaying predictions of what variables will be at some future point in time.

Several such developments are taking place in the United States, but the Japanese have gone ahead and implemented many of the same ideas which for the past few years have been voiced as "wouldn't it be nice if . . . ," by my United States colleagues and me.

* U. S. GOVERNMENT PRINTING OFFICE : 1979 628-147/1998